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HUXLEY'S LIFE AND WORK.*

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I ACCEPTED with pleasure the invitation of your Council to deliver the first Huxley lecture, not only on account of my affection and admiration for him and my long friendship, but it seemed also especially appropriate as I was associated with him in the foundation of this Society. He was President of the Ethnological Society, and when it was fused with the Anthropological we, many of us, felt that Huxley ought to be the first President of the new Institute. No one certainly did so more strongly than your first President, and I only accepted the honor when we found that it was impossible to secure him.

But the foundation of our Institute was only one of the occasions on which we worked together.

Like him, but, of course, far less effectively, from the date of the appearance of the 'Origin of Species,' I stood by Darwin and did my best to fight the battle of truth against the torrent of ignorance and abuse which was directed against him. Sir J. Hooker and I stood by Huxley's side and spoke up for Natural Selection in the great Oxford debate of 1860. In the same year we became co-editors of the 'Natural History Review.'

Another small society in which I was closely associated with Huxley for many years was the X Club. The other members were George Busk, secretary of the Linnean Society; Edward Frankland, president of the Chemical Society; T. A. Hirst, head of the Royal Naval College at Greenwich; Sir Joseph Hooker, Herbert Spencer, W. Spottiswoode,

* The first 'Huxley Memorial Lecture' of the Anthropological Institute, delivered on November 13, 1900.

president of the Royal Society, and Tyndall. It was started in 1864, and nearly nineteen years passed before we had a single loss—that of Spottiswoode; and Hooker, Spencer and I are now, alas! the only remaining members. We used to dine together once a month, except in July, August and September. There were no papers or formal discussions, but the idea was to secure more frequent meetings of a few friends who were bound together by common interests and aims, and strong feelings of personal affection. It has never been formally dissolved, but the last meeting was in 1893.

In 1869 the Metaphysical Society, of which I shall have something more to say later on, was started.

From 1870 to 1875 I was sitting with Huxley on the late Duke of Devonshire's Commission on Scientific Instruction; we had innumerable meetings, and we made many recommendations which are being by degrees adopted.

I had also the pleasure of spending some delightful holidays with him in Switzerland, in Brittany and in various parts of England. Lastly, I sat by his side in the Sheldonian Theater at the British Association meeting at Oxford, during Lord Salisbury's address, to which I listened with all the more interest knowing that he was to second the vote of thanks, and wondering how he would do it. At one passage we looked at one another, and he whispered to me, "Oh, my dear Lubbock, how I wish we were going to discuss the address in Section D instead of here!" Not, indeed, that he would have omitted any part of his speech, but there were other portions of the address which he would have been glad to have criticised. I was, therefore, for many years in close and intimate association with him.

Huxley showed from early youth a determination, in the words of Jean Paul Richter, 'to make the most that was possible out of the stuff,' and this was a great deal, for the material was excellent. He took the wise advice to consume more oil than wine, and, what is better even than midnight oil, he made the most of the sweet morning air.

In his youth he was a voracious reader and devoured everything he could lay his hand on, from the Bible to Hamilton's 'Essay on the Philosophy of the Unconditioned.' He tells us of himself that when he was a mere boy he had a perverse tendency to think when he ought to have been playing.

Considering how preeminent he was as a naturalist, it is rather surprising to hear, as he has himself told us, that his own desire was to be a mechanical engineer. "The only part," he said, "of my professional course which really and deeply interested me was physiology, which is the mechanical engineering of living machines; and, notwithstanding that natural science has been my proper business, I am afraid there is very little of the genuine naturalist in me; I never collected anything,

and species work was a burden to me. What I cared for was the architectural and engineering part of the business; the working out the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modifications of similar apparatus to serve diverse ends."

In 1846 Huxley was appointed naturalist to the expedition which was sent to the East under Captain Owen Stanley in the *Rattlesnake*, and good use, indeed, he made of his opportunities. It is really wonderful, as Sir M. Foster remarks in his excellent obituary notice in the Royal Society's 'Proceedings,' how he could have accomplished so much under such difficulties.

"Working," says Sir Michael Foster, "amid a host of difficulties, in want of room, in want of light, seeking to unravel the intricacies of minute structure with a microscope lashed to secure steadiness, cramped within a tiny cabin, jostled by the tumult of a crowded ship's life, with the scantiest supply of books of reference, with no one at hand of whom he could take counsel on the problems opening up before him, he gathered for himself during those four years a large mass of accurate, important and, in most cases, novel observations, and illustrated them with skilful, pertinent drawings."

The truth is that Huxley was one of those all-round men who would have succeeded in almost any walk in life. In literature his wit, his power of clear description and his admirable style would certainly have placed him in the front rank.

He was as ready with his pencil as with his pen. Every one who attended his lectures will remember how admirably they were illustrated by his blackboard sketches, and how the diagrams seemed to grow line by line almost of themselves. Drawing was, indeed, a joy to him, and when I have been sitting with him at Royal Commissions or on committees, he was constantly making comical sketches on scraps of paper or on blotting-books which, though admirable, never seemed to distract his attention from the subject on hand.

Again, he was certainly one of the most effective speakers of the day. Eloquence is a great gift, although I am not sure that the country might not be better governed and more wisely led if the House of Commons and the country were less swayed by it. There is no doubt, however, that, to its fortunate possessor, eloquence is of great value, and if circumstances had thrown Huxley into political life, no one can doubt that he would have taken high rank among our statesmen. Indeed, I believe his presence in the House of Commons would have been of inestimable value to the country. Mr. Hutton, of the 'Spectator'—no mean judge—has told us that, in his judgment, 'an abler and more accomplished debater was not to be found even in the House of Commons.' His speeches had the same quality, the same luminous style of

exposition, with which his printed books have made all readers in America and England familiar. Yet it had more than that. You could not listen to him without thinking more of the speaker than of his science, more of the solid, beautiful nature than of the intellectual gifts, more of his manly simplicity and sincerity than of all his knowledge and his long services. His Friday evening lectures at the Royal Institution rivaled those of Tyndall in their interest and brilliance, and were always keenly and justly popular. Yet, he has told us that at first he had almost every fault a speaker could have. After his first Royal Institution lecture he received an anonymous letter recommending him never to try again, as whatever else he might be fit for, it was certainly not for giving lectures. It is also said that after one of his first lectures, 'On the Relations of Animals and Plants,' at a suburban Athenæum, a general desire was expressed to the Council that they would never invite that young man to lecture again. Quite late in life he told me, and John Bright said the same thing, that he was always nervous when he rose to speak, though it soon wore off when he warmed up to his subject.

No doubt easy listening on the part of the audience means hard working and thinking on the part of the lecturer, and, whether for the cultivated audience at the Royal Institution or for one to workingmen, he spared himself no pains to make his lectures interesting and instructive. There used to be an impression that Science was something up in the clouds, too remote from ordinary life, too abstruse and too difficult to be interesting; or else, as Dickens ridiculed it in 'Pickwick,' too trivial to be worthy of the time of an intellectual being.

Huxley was one of the foremost of those who brought our people to realize that science is of vital importance in our life, that it is more fascinating than a fairy tale, more thrilling than a novel, and that any one who neglects to follow the triumphant march of discovery, so startling in its marvelous and unexpected surprises, so inspiring in its moral influence and its revelations of the beauties and wonders of the world in which we live and the universe of which we form an infinitesimal, but to ourselves at any rate, an all-important part, is deliberately rejecting one of the greatest comforts and interests of life, one of the greatest gifts with which we have been endowed by Providence.

But there is a time for all things under the sun, and we cannot fully realize the profound interest and serious responsibilities of life unless we refresh the mind and allow the bow to unbend. Huxley was full of humor, which burst out on most unexpected occasions. I remember one instance during a paper on the habits of spiders. The female spider appears to be one of the most unsociable, truculent and bloodthirsty of her sex. Even under the influence of love she does but temporarily suspend her general hatred of all living beings. The courtship varies in

character in different species, and is excessively quaint and curious; but at the close the thirst for blood, which has been temporarily overmastered by an even stronger passion, bursts out with irresistible fury, she attacks her lover and, if he be not on the watch and does not succeed in making his escape, ends by destroying and sucking him dry. In moving a vote of thanks to the author, Huxley ended some interesting remarks by the observation that this closing scene was the most extraordinary form of marriage settlements of which he had ever heard.

He seemed also to draw out the wit of others. At the York 'Jubilee' meeting of the British Association, he and I strolled down in the afternoon to the Minster. At the entrance we met Prof. H. J. Smith, who made a mock movement of surprise. Huxley said: "You seem surprised to see me here." "Well," said Smith hesitatingly, "not exactly, but it would have been on one of the pinnacles, you know."

His letters were full of fun. Speaking of Siena in one of his letters, contained in Mr. Leonard Huxley's excellent Life of his father, he says: "The town is the quaintest place imaginable, built of narrow streets on several hills to start with, and then apparently stirred up with a poker to prevent monotony of effect."

And again, writing from Florence:

"We had a morning at the Uffizi the other day, and came back minds enlarged and backs broken. To-morrow we contemplate attacking the Pitti, and doubt not the result will be similar. By the end of the week our minds will probably be so large, and the small of the back so small, that we should probably break if we stayed any longer, so think it prudent to be off to Venice."

By degrees public duties and honors accumulated on him more and more. He was Secretary, and afterwards President, of the Royal Society, President of the Geological and of the Ethnological Societies, Hunterian Professor from 1863 to 1870, a Trustee of the British Museum, Dean of the Royal College of Science, President of the British Association, Inspector of Fisheries, Member of Senate of the University of London, member of no less than ten Royal Commissions, in addition to which he gave many lectures at the Royal Institution and elsewhere, besides, of course, all those which formed a part of his official duties.

In 1892 he was made a member of the Privy Council, an unwonted but generally welcome recognition of the services which science renders to the community.

As already mentioned, he was elected a Fellow of the Royal Society in 1851. He received a Royal Medal in 1852, the Copley in 1888, and the Darwin Medal in 1894.

Apart from his professional and administrative duties, Huxley's work falls into three principal divisions—Science, Education and Metaphysics.

SCIENTIFIC WORK.

Huxley's early papers do not appear to have in all cases at first received the consideration they deserved. The only important one which was published before his return was the one 'On the Anatomy and Affinities of the Family of the Medusæ.'

After his return, however, there was a rapid succession of valuable Memoirs, the most important, probably, being those on Salpa and Pyrosoma, on Appendicularia and Doliolum and on the Morphology of the Cephalus Mollusca.

In recognition of the value of these Memoirs he was elected a Fellow of the Royal Society in 1851, and received a Royal Medal in 1852. Lord Rosse, in presenting it, said: "In these papers you have for the first time fully developed their (the Medusæ) structure and laid the foundation of a rational theory for their classification." "In your second paper, 'On the Anatomy of Salpa and Pyrosoma,' the phenomena, etc., have received the most ingenious and elaborate elucidation, and have given rise to a process of reasoning the results of which can scarcely yet be anticipated, but must bear, in a very important degree, upon some of the most abstruse points of what may be called transcendental physiology."

A very interesting result of his work on the Hydrozoa was the generalization that the two layers in the bodies of Hydrozoa (Polyps and Sea Anemones), the Ectoderm and the Entoderm correspond with the two primary germ layers of the higher animals. Again, though he did not discover or first define protoplasm, he took no small share in making its importance known, and in bringing naturalists to recognize it as the physical basis of life, and in demonstrating the unity of animal and plant protoplasm.

Among other important memoirs may be mentioned those 'On the Teeth and the Corpuscula Tactus,' 'On the Tegumentary Organs,' 'Review of the Cell Theory,' 'On Aphis,' and many others.

His paleontological work, for which he has told us that at first 'he did not care,' began in 1855. That 'On the Anatomy and Affinities of the Genus Pterygotus' is still a classic; in another, 'On the Structure of the Shields of Pteraspis,' and in one 'On Cephalaspis,' in 1858, he for the first time clearly established their vertebrate character; his work 'On Devonian Fishes' in 1861 threw quite a new light on their affinities; and amongst other later papers may be mentioned that 'On Hyperodapedon;' 'On the Characters of the Pelvis,' 'On the Crayfish,' and one botanical memoir, 'On the Gentians,' the outcome of one of his Swiss trips.

One of the most striking results of his paleontological work was the clear demonstration of the numerous and close affinities between reptiles and birds, the result of which is that they are regarded by many as forming together a separate group, the Sauropsida; while the Amphibia, long regarded as reptiles, were separated from them and united with fishes

under the title of Ichthyopsida. At the same time he showed that the Mammalia were not derived from the Sauropsida, but formed two diverging lines springing from a common ancestor. And besides this great generalization, says the Royal Society obituary notice, "the importance of which, both from a classificatory and from an evolutional point of view, needs no comment, there came out of the same researches numerous lesser contributions to the advancement of morphological knowledge, including, among others, an attempt, in many respects successful, at a classification of birds."

In conjunction with Tyndall, he communicated to the 'Philosophical Transactions' a memoir on glaciers, and his interest in philosophical geography was also shown in his popular treatise on physiography.

But it would be impossible here to go through all his contributions to science. The Royal Society Catalogue enumerates more than a hundred, every one of which, in the words of Prof. S. Parker, "contains some brilliant generalization, some new and fruitful way of looking at the facts of science. The keenest morphological insight and inductive power are everywhere apparent; but the imagination is always kept well in hand, and there are none of those airy speculations—a liberal pound of theory to a bare ounce of fact—by which so many reputations have been made." Huxley never allowed his study of detail to prevent him from taking a wide general view.

I now come to his special work on Man.

In the 'Origin of Species,' Darwin did not directly apply his views to the case of Man. No doubt he assumed that the considerations which applied to the rest of the animal kingdom must apply to Man also, and I should have thought must have been clear to every one, had not Wallace been in some respects, much to my surprise, of a different opinion. At any rate, it required some courage to state this boldly, and much skill and knowledge to state it clearly.

He put it in a manner which was most conclusive, and showed, in Virchow's words, "that in respect of substance and structure Man and the lower animals are one. The fundamental correspondence of human organization with that of animals is at present universally accepted."

This, I think, is too sweeping a proposition. It may be true for Germany, but it certainly is not true here. Many of our countrymen and countrywomen not only do not accept, they do not even understand, Darwin's theory. They seem to suppose him to have held that Man was descended from one of the living Apes. This, of course, is not so. Man is not descended from a Gorilla or an Orang-utang, but Man, the Gorilla, the Orang-utang and other Anthropoid Apes are all descended from some far-away ancestor.

"A Pliocene Homo skeleton," Huxley said, "might analogically be expected to differ no more from that of modern men than the *Œningen*

canis from modern Canes, or Pliocene horses from modern horses. If so, he would most undoubtedly be a man—genus Homo—even if you made him a distinct species. For my part, I should by no means be astonished to find the genus Homo represented in the Miocene, say, the Neanderthal man, with rather smaller brain capacity, longer arms and more movable great toe, but at most specifically different."

In his work 'On Man's Place in Nature,' while referring to the other higher Quadrumana, Huxley dwelt principally on the chimpanzee and the gorilla, because, he said, "It is quite certain that the ape, which most nearly approaches man in the totality of its organization, is either the chimpanzee or the gorilla."

This is no doubt the case at present; but the gibbons (Hylobates), while differing more in size, and modified in adaptation to their more skilful power of climbing, must also be considered, and, to judge from Professor Dubois' remarkable discovery in Java of Pithecanthropus, which half the authorities have regarded as a small man, and half as a large gibbon, it is rather down to Hylobates than either the chimpanzee or the gorilla that we shall have to trace the point where the line of our far-away ancestors will meet that of any existing genus of monkeys.

Huxley emphasized the fact that monkeys differ from one another in bodily structure as much or more than they do from man.

We have Haeckel's authority for the statement that "after Darwin had, in 1859, reconstructed this most important biological theory, and by his epoch-making theory of natural selection placed it on an entirely new foundation, Huxley was the first who extended it to man; and, in 1863, in his celebrated three lectures on 'Man's Place in Nature,' admirably worked out its most important developments."

The work was so well and carefully done that it stood the test of time, and, writing many years afterwards, Huxley was able to say, and to say truly, that:

"I was looking through 'Man's Place in Nature' the other day; I do not think there is a word I need delete, nor anything I need add except in confirmation and extension of the doctrine there laid down. That is great good fortune for a book thirty years old, and one that a very shrewd friend of mine implored me not to publish, as it would certainly ruin all my prospects" ('Life of Professor Huxley,' p. 344).

He has told us elsewhere ('Collected Essays,' vii., p. 11) that "it has achieved the fate which is the Euthanasia of a scientific work, of being inclosed among the rubble of the foundations of knowledge and forgotten." He has, however, himself saved it from the tomb, and built it into the walls of the temple of science, and it will still well repay the attention of the student.

For a poor man—I mean poor in money, as Huxley was all his life—

to publish such a book at that time was a bold step. But the prophecy with which he concluded the work is coming true.

"After passion and prejudice have died away," he said, "the same result will attend the teachings of the naturalist respecting that great Alps and Andes of the living world—Man. Our reverence for the nobility of manhood will not be lessened by the knowledge that man is, in substance and in structure, one with the brutes; for he alone possesses the marvelous endowments of intelligible and rational speech, whereby, in the secular period of his existence, he has slowly accumulated and organized the experience which is almost wholly lost with the cessation of every individual life in other animals; so that now he stands raised upon it as on a mountain top—far above the level of his humble fellows, and transfigured from his grosser nature by reflecting here and there a ray from the infinite source of truth" ('Collected Essays,' vii., p. 155).

Another important research connected with the work of our Society was his investigation of the structure of the vertebrate skull. Owen had propounded a theory and worked it out most ingeniously that the skull was a complicated elaboration of the anterior part of the back-bone; that it was gradually developed from a preconceived idea or archetype; that it was possible to make out a certain number of vertebræ, and even the separate parts of which they were composed.

Huxley maintained that the archetypal theory was erroneous; and that, instead of being a modification of the anterior part of the primitive representative of the back-bone, the skull is rather an independent growth around and in front of it. Subsequent investigations have strenghtened this view, which is now generally accepted. This lecture marked an epoch in vertebrate morphology, and the views he enunciated still hold the field.

One of the most interesting parts of Huxley's work, and one specially connected with our Society, was his study of the ethnology of the British Isles. It has also an important practical and political application, because the absurd idea that ethnologically the inhabitants of our islands form three nations—the English, Scotch and Irish—has exercised a malignant effect on some of our statesmen, and is still not without influence on our politics. One of the strongest arguments put forward in favor of Home Rule used to be that the Irish were a 'nation.' In 1887 I attacked this view in some letters to the 'Times,' subsequently published by Quaritch. Nothing is more certain than that there was not a Scot in Scotland till the seventh century; that the east of our island from John o' Groat's House to Kent is Teutonic; that the most important ethnological line, so far as there is one at all, is not the boundary between England and Scotland, but the north and south watershed which separates the east and west. In Ireland, again, the population is far from homogeneous. Huxley strongly supported the position I had

taken up. "We have," he said, "as good evidence as can possibly be obtained on such subjects that the same elements have entered into the composition of the population in England, Scotland and Ireland; and that the ethnic differences between the three lie simply in the general and local proportions of these elements in each region. . . . The population of Cornwall and Devon has as much claim to the title of Celtic as that of Tipperary. . . . Undoubtedly there are four geographical regions, England, Scotland, Wales and Ireland, and the people who live in them call themselves and are called by others the English, Scotch, Welsh and Irish nations. It is also true that the inhabitants of the Isle of Man call themselves Manxmen, and are just as proud of their nationality as any other 'nationalities.'

. . . . . .

"But if we mean no more than this by 'nationality,' the term has no practical significance" ('The Races of the British Isles,' pp. 44, 45).

Surely it would be very desirable, especially when political arguments are based on the term, that we should come to some understanding as to what is meant by the word 'nation.' The English, Scotch and Irish live under one Flag, one Queen and one Parliament. If they are not one nation, what are they? What term are we to use, and some term is obviously required, to express and combine all three. For my part I submit that the correct terminology is to speak of Celtic race or Teutonic race, of the Irish people or the Scotch people; but that the people of England, Scotland and Ireland, aye, and of the Colonies also, constitute one great nation.

As regards the races which have combined to form the nation, Huxley's view was that in Roman times the population of Britain comprised people of two types, the one fair, the other dark. The dark people resembled the Aquitani and the Iberians; the fair people were like the Belgic Gauls ('Essays,' V., vii., p. 254). And he adds that "the only constituent stocks of that population, now, or at any other period about which we have evidence, are the dark whites, whom I have proposed to call 'Melanochroi,' and the fair whites or 'Xanthochroi.'"

He concludes (1) "That the Melanochroi and the Xanthochroi are two separate races in the biological sense of the word race; (2) that they have had the same general distribution as at present from the earliest times of which any record exists on the continent of Europe; (3) that the population of the British Islands is derived from them, and from them only."

It will, however, be observed that we have (1) a dark race and a fair race; (2) a large race and a small race; and (3) a round-headed race and a long-headed race. But some of the fair race were large, some small; some have round heads, some long heads; some of the dark race again had long heads, some round ones. In fact, the question seems to me

more complicated than Huxley supposed. The Mongoloid races extend now from China to Lapland; but in Huxley's opinion they never penetrated much further west, and never reached our islands. "I am unable," he says, "to discover any ground for believing that a Lapp element has ever entered into the population of these islands." It is true that we have not, so far as I know, anything which amounts to proof. We know, however, that all the other animals which are associated with the Lapps once inhabited Great Britain. Was man the only exception? I think not, more especially when we find, not only the animals of Lapland, but tools and weapons identical with those of the Lapps. I must not enlarge on this, and perhaps I may have an opportunity of laying my views on the subject more fully before the Society; but I may be allowed to indicate my own conclusion, namely, that the races to which Huxley refers are amongst the latest arrivals in our islands; that England was peopled long before its separation from the mainland, and that after the English Channel was formed, successive hordes of invaders made their way across the sea, but as they brought no women, or but few, with them, they exterminated the men, or reduced them to slavery, and married the women. Thus through their mothers our countrymen retain the strain of previous races, and hence, perhaps, we differ so much from the populations across the silver streak.

Summing up this side of Huxley's work, Sir M. Foster has truly said that "whatever bit of life he touched in his search, protozoan, polyp, mollusc, crustacean, fish, reptile, beast and man—and there were few living things he did not touch—he shed light on it, and left his mark. There is not one, or hardly one, of the many things which he has written which may not be read again to-day with pleasure and with profit, and, not once or twice only in such a reading, it will be felt that the progress of science has given to words written long ago a strength and meaning even greater than that which they seemed to have when first they were read."

In 1870 Huxley became a member of the first London School Board, and though his health compelled him to resign early in 1872, it would be difficult to exaggerate the value of the service he rendered to London and, indeed, to the country generally.

The education and discipline which he recommended were:

(1) Physical training and drill.

(2) Household work or domestic economy, especially for girls.

(3) The elementary laws of conduct.

(4) Intellectual training, reading, writing and arithmetic, elementary science, music and drawing.

He maintained that 'no boy or girl should leave school without possessing a grasp of the general character of science, and without having been disciplined more or less in the methods of all sciences.'

As regards the higher education, he was a strong advocate for science and modern languages, though without wishing to drop the classics.

Some years ago, for an article on higher education, I consulted a good many of the highest authorities on the number of hours per week which, in their judgment, should be given to the principal subjects. Huxley, amongst others, kindly gave me his views. He suggested ten hours for ancient languages and literature, ten for modern languages and literature, eight for arithmetic and mathematics, eight for science, two for geography and two for religious instruction.

For my own part I am firmly convinced that the amount of time devoted to classics has entirely failed in its object. The mind is like the body—it requires change. Mutton is excellent food; but mutton for breakfast, mutton for lunch, and mutton for dinner would soon make any one hate the sight of mutton, and so, Latin grammar before breakfast, Latin grammar before lunch, and Latin grammar before dinner is enough to make almost any one hate the sight of a classical author. Moreover, the classics, though an important part, are not the whole of education, and a classical scholar, however profound, if he knows no science, is but a half-educated man after all.

In fact, Huxley was no opponent of a classical education in the proper sense of the term, but he did protest against it in the sense in which it is usually employed, namely, as an education from which science is excluded, or represented only by a few random lectures.

He considered that specialization should not begin till sixteen or seventeen. At present we begin in our Public School system to specialize at the very beginning, and to devote an overwhelming time to Latin and Greek, which, after all, the boys are not taught to speak. Huxley advocated the system adopted by the founders of the University of London, and maintained to the present day that no one should be given a degree who did not show some acquaintance with science and with at least one modern language.

"As for the so-called 'conflict of studies,'" he exclaims, "one might as well inquire which of the terms of a Rule of Three sum one ought to know in order to get a trustworthy result. Practical life is such a sum, in which your duty multiplied into your capacity, and divided by your circumstances, gives you the fourth term in the proportion, which is your deserts, with great accuracy" ('Life of Professor Huxley,' p. 406).

"That man," he said, "I think, has had a liberal education, who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge

of the great and fundamental truths of nature and the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of nature or of art, to hate all vileness and to respect others as himself."

He was also strongly of opinion that colleges should be places of research as well as of teaching.

"The modern university looks forward, and is a factory of new knowledge; its professors have to be at the top of the wave of progress. Research and criticism must be the breath of their nostrils; laboratory work the main business of the scientific student; books his main helpers."

Education has been advocated for many good reasons: by statesmen because all have votes, by Chambers of Commerce because ignorance makes bad workmen, by the clergy because it makes bad men, and all these are excellent reasons; but they may all be summed up in Huxley's words that "the masses should be educated because they are men and women with unlimited capacities of being, doing and suffering, and that it is as true now as ever it was that the people perish for lack of knowledge."

Huxley once complained to Tyndall, in joke, that the clergy seemed to let him say anything he liked, 'while they attack me for a word or a phrase.' But it was not always so.

Tyndall and I went, in the spring of 1874, to Naples to see an eruption of Vesuvius. At one side the edge of the crater shelved very gradually to the abyss, and, being anxious to obtain the best possible view, I went a little over the ridge. In the autumn Tyndall delivered his celebrated address to the British Association at Belfast. This was much admired, much read, but also much criticised, and one of the papers had an article on Huxley and Tyndall, praising Huxley very much at Tyndall's expense, and ending with this delightful little bit of bathos: "In conclusion, we do not know that we can better illustrate Professor Tyndall's foolish recklessness, and the wise, practical character of Professor Huxley, than by mentioning the simple fact that last spring, at the very moment when Professor Tyndall foolishly entered the crater of Vesuvius during an eruption, Professor Huxley, on the contrary, took a seat on the London School Board."

Tyndall, however, returned from Naples with fresh life and health, while the strain of the School Board told considerably on Huxley's health.

Huxley's attitude on the School Board with reference to Bible teaching came as a surprise to those who did not know him well. He supported Mr. W. H. Smith's motion in its favor, which, indeed, was voted

for by all the members except six, three of whom were the Roman Catholics, who did not vote either way.

"I have been," he said, "seriously perplexed to know by what practical measures the religious feeling, which is the essential basis of conduct, was to be kept up, in the present utterly chaotic state of opinion on these matters, without the use of the Bible. Take the Bible as a whole; make the severest deductions which fair criticism can dictate for short-comings and positive errors; eliminate, as a sensible lay-teacher would do if left to himself, all that it is not desirable for children to occupy themselves with; and there still remains in this old literature a vast residuum of moral beauty and grandeur. And then consider the great historical fact that for three centuries this book has been woven into the life of all that is best and noblest in English history; that it has become the national epic of Britain, and is as familiar to noble and simple, from John o' Groat's House to Land's End, as Dante and Tasso were once to Italians; that it is written in the noblest and purest English, and abounds in exquisite beauties of mere literary form; and, finally, that it forbids the veriest hind who never left his village to be ignorant of the existence of other countries and other civilizations, and of a great past, stretching back to the furthest limits of the oldest nations in the world. By the study of what other book could children be so much humanized and made to feel that each figure in that vast historical procession fills, like themselves, but a momentary space in the interval between two eternities, and earns the blessings or the curses of all time, according to its effort to do good and hate evil, even as they also are earning their payment for their work?"

Another remarkable side of Huxley's mind was his interest in and study of metaphysics. When the Metaphysical Society was started in 1869, there was some doubt among the promoters whether Huxley and Tyndall should be invited to join or not. Mr. Knowles was commissioned to come and consult me. I said at once that to draw the line at the opinions which they were known to hold would, as it seemed to me, limit the field of discussion, and there would always be doubts as to when the forbidden region began; that I had understood there was to be perfect freedom, and that though Huxley's and Tyndall's views might be objectionable to others of our members, I would answer for it that there could be nothing in the form of expression of which any just complaint could be made.

The society consisted of about forty members, and when we consider that they included Thompson, Archbishop of York, Ellicott, Bishop of Gloucester and Bristol, Dean Stanley and Dean Alford as representatives of the Church of England; Cardinal Manning, Father Dalgairns and W. G. Ward as Roman Catholics; among statesmen, Gladstone, the late Duke of Argyll, Lord Sherbrooke, Sir M. Grant Duff, John Morley,

as well as Martineau, Tennyson, Browning, R. H. Hutton, W. Bagehot, Frederic Harrison, Leslie Stephen, Sir J. Stephen, Dr. Carpenter, Sir W. Gull, W. R. Greg, James Hinton, Shadworth Hodgson, Lord Arthur Russell, Sir Andrew Clark, Sir Alexander Grant, Mark Patteson and W. K. Clifford, it will not be wondered that I looked forward to the meetings with the greatest interest. I experienced also one of the greatest surprises of my life. We all, I suppose, wondered who would be the first President. No doubt what happened was that Roman Catholics objected to Anglicans, Anglicans to Roman Catholics, both to Nonconformists; and the different schools of metaphysics also presented difficulties, so that finally, to my amazement, I found myself the first President! The discussions were perfectly free, but perfectly friendly; and I quite agree with Mr. H. Sidgwick, that Huxley was one of the foremost, keenest and most interesting debaters, which, in such a company, is indeed no slight praise.

We dined together, then a paper was read, which had generally been circulated beforehand, and then it was freely discussed, the author responding at the close. Huxley contributed several papers, but his main contribution to the interest of the Society was his extraordinary ability and clearness in debate.

His metaphysical studies led to his work on Hume and his memoirs on the writings of Descartes.

One of his most interesting treatises is a criticism of Descartes' theory of animal automatism. Descartes was not only a great philosopher, but also a great naturalist, and we owe to him the definite allocation of all the phenomena of consciousness to the brain. This was a great step in science, but, just because Descartes' views have been so completely incorporated with everyday thought, few of us realize how recently it was supposed that the passions were seated in the apparatuses of organic life. Even now we speak of the heart rather than the brain in describing character.

Descartes, as is known, was much puzzled as to the function of one part of the brain—a small, pear-shaped body about the size of a nut, and deeply seated. Known as the pineal gland, he suggested that it was the seat of the soul; but it is now regarded, and apparently on solid grounds, as the remains of the optic lobe of a central eye once possessed by our far-away ancestors, and still found in some animals, as, for instance, in certain lizards. Descartes was much impressed by the movements which are independent of consciousness or volition, and known as reflex actions—such, for instance, as the winking of the eye or the movement of the leg if the sole of the foot is touched. This takes place equally if, by any injury to the spinal marrow, the sensation in the legs has been destroyed.

Such movements appear to be more frequent among lower animals,

and Descartes supposed that all their movements might be thus accounted for—that they were, like the movements of sensitive plants, absolutely detached from consciousness or sensation, and that, in fact, animals were mere machines or automata, devoid not only of reason, but of any kind of consciousness.

It must be admitted that Descartes' arguments are not easy to disprove, and no doubt certain cases of disease or injury—as, for instance, that of the soldier described by Dr. Mesnet, who, as a result of a wound in the head, fell from time to time into a condition of unconsciousness, during which, however, he ate, drank, smoked, dressed and undressed, and even wrote—have supplied additional evidence in support of his views. Huxley, while fully admitting this, came, and I think rightly, to the conclusion that the consciousness of which we feel certain in ourselves must have been evolved very gradually, and must therefore exist, though probably in a less degree, in other animals.

No one, indeed, I think, who has kept and studied pets, even if they be only ants and bees, can bring himself to regard them as mere machines.

The foundation of the Metaphysical Society led to the invention of the term 'Agnostic.'

"When I reached intellectual maturity," Huxley tells us, "and began to ask myself whether I was an atheist, a theist or a pantheist, a materialist or an idealist, a Christian or a freethinker, I found that the more I learned and reflected, the less ready was the answer; until, at last, I came to the conclusion that I had neither art nor part with any of these denominations except the last. The one thing in which most of these good people were agreed was the one thing in which I differed from them. They were quite sure they had attained a certain 'gnosis'—had, more or less successfully, solved the problem of existence; while I was quite sure I had not, and had a pretty strong conviction that the problem was insoluble. . . ."

These considerations pressed forcibly on him when he joined the Metaphysical Society.

"Every variety," he says, "of philosophical and theological opinion was represented there, and expressed itself with entire openness; most of my colleagues were 'ists' of one sort or another; and, however kind and friendly they might be, I, the man without a rag of a habit to cover himself with, could not fail to have some of the uneasy feelings which must have beset the historical fox when, after leaving the trap, in which his tail remained, he presented himself to his normally elongated companions. So I took thought, and invented what I conceived to be the appropriate title of agnostic. It came into my head as suggestively antithetic to the gnostic of Church history, who professed to know so much about the very things of which I was ignorant; and I took the

earliest opportunity of parading it at our Society, to show that I, too, had a tail like the other foxes."

Huxley denied that he was disposed to rank himself either as a fatalist, a materialist or an atheist. "Not among fatalists, for I take the conception of necessity to have a logical, and not a physical, foundation; not among materialists, for I am utterly incapable of conceiving the existence of matter if there is no mind in which to picture that existence; not among atheists, for the problem of the ultimate cause of existence is one which seems to me to be hopelessly out of reach of my poor powers."

The late Duke of Argyll, in his interesting work on 'The Philosophy of Belief,' makes a very curious attack on Huxley's consistency. He observes that scientific writers use "forms of expression as well as individual words, all of which are literally charged with teleological meaning. Men even who would rather avoid such language if they could, but who are intent on giving the most complete and expressive description they can of the natural facts before them, find it wholly impossible to discharge this duty by any other means. Let us take as an example the work of describing organic structures in the science of biology. The standard treatise of Huxley on the 'Elements of Comparative Anatomy,' affords a remarkable example of this necessity, and of its results. . . .

"How unreasonable it is to set aside, or to explain away, the full meaning of such words as 'apparatuses' and 'plans,' comes out strongly when we analyze the preconceived assumptions which are supposed to be incompatible with the admission of it. . . .

"To continue the use of words because we are conscious that we cannot do without them, and then to regret or neglect any of their implications, is the highest crime we can commit against the only faculties which enable us to grasp the realities of the world." Is not this, however, to fall into the error of some Greek philosophers, and to regard language, not only as a means of communication, but as an instrument of research. We all speak of sunrise and sunset, but it is no proof that the sun goes round the earth. The Duke himself says elsewhere:

"We speak of time as if it were an active agent in doing this, that and the other. Yet we are quite conscious, when we choose to think of it, that when we speak of time in this sense, we are really thinking and speaking, not of time itself, but of the various physical forces which operate slowly and continuously in, or during, time. Apart from these forces, time does nothing."

This is, it seems to me, a complete reply to his own attack on Huxley's supposed inconsistency.

Theologians often seem to speak as if it were possible to believe something which one cannot understand, as if the belief were a matter

of will, that there was some merit in believing what you cannot prove, and that if a statement of fact is put before you, you must either believe it or disbelieve it. Huxley, on the other hand, like most men of science, demanded clear proof, or what seemed to him clear proof, before he accepted any conclusion; he would, I believe, have admitted that you might accept a statement which you could not explain, but would have maintained that it was impossible to believe what you did not understand; that in such a case the word 'belief' was an unfortunate misnomer; that it was wrong, and not right, to profess to believe anything for which you knew that there was no sufficient evidence, and that if it is proved you cannot help believing it; that as regards many matters the true position was not one either of belief or of disbelief, but of suspense.

In science we know that though the edifice of fact is enormous, the fundamental problems are still beyond our grasp, and we must be content to suspend our judgment, to adopt, in fact, the Scotch verdict of 'not proven,' so unfortunately ignored in our law as in our theology.

Faith is a matter more of deeds, not of words, as St. Paul shows in the Epistle to the Hebrews. If you do not act on what you profess to believe, you do not really and in truth believe it. May I give an instance? The Fijians really believed in a future life; according to their creed, you rose in the next world exactly as you died here—young if you were young, old if you were old, strong if you were strong, deaf if you were deaf, and so on. Consequently it was important to die in the full possession of one's faculties; before the muscles had begun to lose their strength, the eye to grow dim, or the ear to wax hard of hearing. On this they acted. Every one had himself killed in the prime of life; and Captain Wilkes mentions that in one large town there was not a single person over forty years of age.

That I call faith. That is a real belief in a future life.

Huxley's views are indicated in the three touching lines by Mrs. Huxley, which are inscribed on his tombstone:

> Be not afraid, ye wailing hearts that weep,
> For still He giveth His beloved sleep,
> And if an endless sleep He wills—so best.

That may be called unbelief, or a suspension of judgment. Huxley doubted.

But disbelief is that of those who, no matter what they say, act as if there was no future life, as if this world was everything, and in the words of Baxter in 'The Saints' Everlasting Rest,' profess to believe in Heaven, and yet act as if it was to be 'tolerated indeed rather than the flames of Hell, but not to be desired before the felicity of Earth.'

Huxley was, indeed, by no means without definite beliefs. "I am," he said, "no optimist, but I have the firmest belief that the Divine Government (if we may use such a phrase to express the sum of the 'customs

of matter') is wholly just. The more I know intimately of the lives of other men (to say nothing of my own), the more obvious it is to me that the wicked does not flourish nor is the righteous punished."

One of the great problems of the future is to clear away the cobwebs which the early and mediæval ecclesiastics, unavoidably ignorant of science, and with ideas of the world now known to be fundamentally erroneous, have spun round the teachings of Christ; and in this Huxley rendered good service. For instance, all over the world in early days lunatics were supposed to be possessed by evil spirits. That was the universal belief of the Jews, as of other nations, 2,000 years ago, and one of Huxley's most remarkable controversies was with Mr. Gladstone and Dr. Wace with reference to the 'man possessed with devils,' which, we are told, were cast out and permitted to enter into a herd of swine. Some people thought that these three distinguished men might have occupied their time better than, as was said at the time, 'in fighting over the Gaderene swine.' But as Huxley observed:

"The real issue is whether the men of the nineteenth century are to adopt the demonology of the men of the first century as divinely revealed truth, or to reject it as degrading falsity."

And as the first duty of religion is to form the highest conception possible to the human mind of the Divine Nature, Huxley naturally considered that when a Prime Minister and Doctor of Divinity propound views showing so much ignorance of medical science, and so low a view of the Deity, it was time that a protest was made in the name, not only of science, but of religion.

Theologians themselves, indeed, admit the mystery of existence. "The wonderful world," says Canon Liddon, "in which we now pass this stage of our existence, whether the higher world of faith be open to our gaze or not, is a very temple of many and august mysteries. . . . Everywhere around you are evidences of the existence and movement of a mysterious power which you can neither see, nor touch, nor define, nor measure, nor understand."

One of Huxley's difficulties he has stated in the following words: "Infinite benevolence need not have invented pain and sorrow at all—infinite malevolence would very easily have deprived us of the large measure of content and happiness that falls to our lot."

This does not, I confess, strike one as conclusive. It seems an answer—if not perhaps quite complete, that if we are to have any freedom and responsibility, the possibility of evil follows necessarily. If two courses are open to us, there are two alternatives; either the results are the same in either case, and then it does not matter what we do; or the one course must be wise and the other unwise. Huxley, indeed, said in another place: "I protest that if some great power could agree to make me always think what is true, and do what is right, on condition of being

turned into a sort of a clock and wound up every morning before I got out of bed, I should instantly close with the offer. The only freedom I care about is the freedom to do right; the freedom to do wrong I am ready to part with on the cheapest terms to any one who will take it of me. But when the Materialists stray beyond the borders of their path, and talk about there being nothing else in the world but Matter and Forces and necessary laws, ... I decline to follow them."

Huxley was no enemy to the existence of an Established Church.

"I could conceive," he said, "the existence of an Established Church which should be a blessing to the community. A church in which, week by week, services should be devoted, not to the iteration of abstract propositions in theology, but to the setting before men's minds of an ideal of true, just and pure living; a place in which those who are weary of the burden of daily cares should find a moment's rest in the contemplation of the higher life which is possible for all, though attained by so few; a place in which the man of strife and of business should have time to think how small, after all, are the rewards he covets compared with peace and charity. Depend upon it, if such a Church existed, no one would seek to disestablish it."

It seems to me that he has here very nearly described the Church of Stanley, of Jowett, and of Kingsley.

Sir W. Flower justly observed that "if the term 'religious' be limited to acceptance of the formularies of one of the current creeds of the world, it cannot be applied to Huxley; but no one could be intimate with him without feeling that he possessed a deep reverence for 'whatsoever things are true, whatsoever things are honest, whatsoever things are just, whatsoever things are pure, whatsoever things are lovely, whatsoever things are of good report,' and an abhorrence of all that is the reverse of these; and that, although he found difficulty in expressing it in definite words, he had a pervading sense of adoration of the infinite, very much akin to the highest religion."

Lord Shaftesbury records that "Professor Huxley has this definition of morality and religion: 'Teach a child what is wise, that is morality. Teach him what is wise and beautiful, that is religion!' Let no one henceforth despair of making things clear and of giving explanations!" ('Life and Works,' iii., 282).

I doubt, indeed, whether the debt which Religion owes to Science has yet been adequately acknowledged.

The real conflict—for conflict there has been and is—is not between Science and Religion, but between Science and Superstition. A disbelief in the goodness of God led to all the horrors of the Inquisition. Throughout the Middle Ages and down almost to our own times, as Lecky has so powerfully shown, the dread of witchcraft hung like a black pall over Christianity. Even so great and good a man as Wesley

believed in it. It is Science which has cleared away these dark clouds, and we can hardly fail to see that it is just in those countries where Science is most backward that Religion is less well understood, and in those where Science is most advanced that Religion is purest. The services which Science has rendered to Religion have not as yet, I think, received the recognition they deserve.

Many of us may think that Huxley carried his scepticism too far, that some conclusions which he doubted, if not indeed proved, yet stand on a securer basis than he supposed.

He approached the consideration of these awful problems, however, in no scoffing spirit, but with an earnest desire to arrive at the truth, and I am glad to acknowledge that this has been generously recognized by his opponents.

From his own point of view, Huxley was no opponent of Religion, however fundamentally he might differ from the majority of clergymen. In Science we differ, but we are all seeking for truth, and we do not dream that any one is an enemy to 'science.'

In Theology, however, unfortunately as we think, a different standard has been adopted. Theologians often, though no doubt there are many exceptions, regard a difference from themselves as an attack on religion, a suspension of judgment as an adverse verdict, and doubt as infidelity.

It is, therefore, only just to them to say that their obituary notices of Huxley were fair and even generous. When they treated him as a foe they did so, as a rule, in a spirit as honorable to them as it was to him.

The 'Christian World,' in a very interesting obituary notice, truly observed that "if in Huxley's earlier years the average opinion of the churches had been as ready as it is now to accept the evolution of the Bible, it would not have been so startled by Darwin's theory of the evolution of man; and Darwin's greatest disciple would have enjoyed thirty years ago the respect and confidence and affection with which we came to regard him before we lost him."

"Surely it is a striking and suggestive fact that both the retiring and the incoming President of the Royal Society, by way of climax to their eulogies, dwelt on the religious side of Huxley's character. "If religion means strenuousness in doing right, and trying to do right, who," asked Lord Kelvin, "has earned the title of a religious man better than Huxley?" And similarly Sir J. Lister, in emphasizing Huxley's intellectual honesty, "his perfect truthfulness, his whole-hearted benevolence," felt impelled to adopt Lord Kelvin's word and celebrate "the religion that consists in the strenuous endeavor to be and do what is right."

Huxley was not only a great man, but a good and a brave one. It required much courage to profess his opinions, and if he had consulted

only his own interests he would not have done so, but we owe much to him for the inestimable freedom which we now enjoy.

When he was moved to wrath it was when he thought wrong was being done, the people were being misled, or truth was being unfairly attacked, as, for instance, in the celebrated discussion at Oxford. The statue in the Natural History Museum is very powerful and a very exact likeness, but it is like him when he was moved to righteous indignation. It is not Huxley as he was generally, as he was when he was teaching, or when in the company of friends. He was one of the most warm-hearted and genial of men. Mr. Hutton, who sat with him on the Vivisection Commission, has recorded that "considering he represented the physiologists on this Commission, I was much struck with his evident horror of anything like torture even for scientific ends." I do not, however, see why this should have surprised him, because the position of physiologists is that it is the anti-vivisectionists who would enormously increase the suffering in the world. To speak of inflicting pain 'for scientific ends' is misleading. It is not for the mere acquisition of useless knowledge, but for the diminution of suffering and because one experiment may prevent thousands of mistakes and save hundreds of lives. The medical profession may be mistaken in this, but it is obvious that their conviction, whether it be right or whether it be wrong, is not only compatible with, but is inspired by, a horror of unnecessary suffering.

The great object of his labors was, in his own words, "to promote the increase of natural knowledge and to forward the application of scientific methods of investigation to all the problems of life." His family life was thoroughly happy. He was devoted to his children, and they to him. "The love our children show us," he said in one of his letters, "warms our old age better than the sun."

Nor can I conclude without saying a word about Mrs. Huxley, of whom her son justly says that she was "his help and stay for forty years, in his struggles ready to counsel, in adversity to comfort; the critic whose judgment he valued above almost any, and whose praise he cared most to win; his first care and latest thought, the other self, whose union with him was a supreme example of mutual sincerity and devotion."

At a time of deep depression and when his prospects looked most gloomy he mentions a letter from Miss Heathorn as having given him "more comfort than anything for a long while. I wish to Heaven," he says, "it had reached me six months ago. It would have saved me a world of pain and error."

Huxley had two great objects in life as he has himself told us. "There are," he said, "two things I really care about—one is the progress of scientific thought, and the other is the bettering of the condition of the masses of the people by bettering them in the way of lifting them-

selves out of the misery which has hitherto been the lot of the majority of them. Posthumous fame is not particularly attractive to me, but, if I am to be remembered at all, I would rather it should be as 'a man who did his best to help the people' than by any other title."

It is not only because we, many of us, loved him as a friend, not only because we all of us recognize him as a great naturalist, but also because he was a great example to us all, a man who did his best to benefit the people, that we are here to do honor to his memory to-day.

MALARIA.*

By GEO. M. STERNBERG, M.D., LL.D.,
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IN my address as president of the Biological Society, in 1896, the subject chosen was 'The Malarial Parasite and other Pathogenic Protozoa.' This address was published in March, 1897, in the POPULAR SCIENCE MONTLHY, and I must refer you to this illustrated paper for a detailed account of the morphological characters of the malarial parasite. It is my intention at the present time to speak of 'Malaria' in a more general way and of the recent experimental evidence in support of Manson's suggestion, first made in 1894, that the mosquito serves as an intermediate host for the parasite. The discovery of this parasite may justly be considered one of the greatest achievements of scientific research during the nineteenth century. Twenty-five years ago the best-informed physicians entertained erroneous ideas with reference to the nature of malaria and the etiology of the malarial fevers. Observation had taught them that there was something in the air in the vicinity of marshes in tropical regions, and during the summer and autumn in semi-tropical and temperate regions, which gave rise to periodic fevers in those exposed in such localities, and the usual inference was that this something was of gaseous form—that it was a special kind of bad air generated in swampy localities under favorable meteorological conditions. It was recognized at the same time that there are other kinds of bad air, such as the offensive emanations from sewers and the products of respiration of man and animals, but the term malaria was reserved especially for the kind of bad air which was supposed to give rise to the so-called malarial fevers. In the light of our present knowledge it is evident that this term is a misnomer. There is no good reason for believing that the air of swamps is any more deleterious to those who breathe it than the air of the sea coast or that in the vicinity of inland lakes and ponds. Moreover, the stagnant pools, which are covered with a 'green scum' and from which bubbles of gas are given off, have lost all terrors for the well-informed man, except in so far as they serve as breeding places for mosquitoes of the genus *Anopheles*. The green scum is made up of harmless algæ such as Spirogyra, Zygnema Protococcus, Euglena, etc.; and the gas which is given off from the mud at the bottom of such stagnant pools is for the most part a well-known and comparatively harmless compound

* Annual address of the president of the Philosophical Society of Washington. Delivered under the auspices of the Washington Academy of Sciences, on December 8, 1900.

of hydrogen and carbon—methane or 'marsh-gas.' In short, we now know that the air in the vicinity of marshes is not deleterious because of any special kind of bad air present in such localities, but because it contains mosquitoes infected with a parasite known to be the specific cause of the so-called malarial fevers. This parasite was discovered in the blood of patients suffering from intermittent fevers by Laveran, a surgeon in the French army, whose investigations were conducted in Algiers. This famous discovery was made toward the end of the year 1880, but it was several years later before the profession generally began to attach much importance to the alleged discovery. It was first confirmed by Richard in 1882; then by the Italian investigators, Marchiafava, Celli, Golgi and Bignami; by Councilman, Osler and Thayer in this country, and by many other competent observers in various parts of the world. The Italian investigators named not only confirmed the presence of the parasite discovered by Laveran in the blood of those suffering from malarial fevers, but they demonstrated its etiological rôle by inoculation experiments and added greatly to our knowledge of its life history (1883-1898). The fact that the life history of the parasite includes a period of existence in the body of the mosquito, as an intermediate host, has recently been demonstrated by the English army surgeons Manson and Ross, and confirmed by numerous observers, including the famous German bacteriologist, Koch.

The discoveries referred to, as is usual, have had to withstand the criticism of conservative physicians, who, having adopted the prevailing theories with reference to the etiology of periodic fevers, were naturally skeptical as to the reliability of the observations made by Laveran and those who claimed to have confirmed his discovery. The first contention was that the bodies described as present in the blood were not parasites, but deformed blood corpuscles. This objection was soon set at rest by the demonstration, repeatedly made, that the intra-corpuscular forms underwent distinct amœboid movements. No one witnessing these movements could doubt that he was observing a living microorganism. The same was true of the extra-corpuscular flagellate bodies, which may be seen to undergo very active movements, as a result of which the red blood corpuscles are violently displaced and the flagellate body itself dashes about in the field of view.

The first confirmation in this country of Laveran's discovery of amœboid parasites in the blood of malarial-fever patients was made by myself in the pathological laboratory of the Johns Hopkins University in March, 1886. In May, 1885, I had visited Rome as a delegate to the International Sanitary Conference, convened in that city under the auspices of the Italian Government, and while there I visited the Santo Spirito Hospital for the purpose of witnessing a demonstration, by Drs. Marchiafava and Celli, of that city, of the presence of the *plasmodium*

malariæ in the blood of persons suffering from intermittent fever. Blood was drawn from the finger during the febrile attack and from individuals to whom quinine had not been administered. The demonstration was entirely satisfactory, and no doubt was left in my mind that I saw living parasitic micro-organisms in the interior of red blood corpuscles obtained from the circulation of malarial-fever patients. The motions were quite slow and were manifested by a gradual change of outline rather than by visible movement. After a period of amœboid activity of greater or less duration, the body again assumed an oval or spherical form and remained quiescent for a time. While in this form it was easily recognized, as the spherical shape caused the light passing through it to be refracted and gave the impression of a body having a dark contour and a central vacuole; but when it was flattened out and undergoing amœboid changes in form, it was necessary to focus very carefully and to have a good illumination in order to see it. The objective used was a Zeiss's one-twelfth inch homogeneous oil immersion.

But, very properly, skepticism with reference to the causal relation of these bodies to the disease with which they are associated was not removed by the demonstration that they are in fact blood-parasites, that they are present in considerable numbers during the febrile paroxysms and that they disappear during the interval between these paroxysms. These facts, however, give strong support to the inference that they are indeed the cause of the disease. This inference is further supported by the evident destruction of red blood corpuscles by the parasite, as shown by the presence of grains of black pigment in the amœba-like micro-organisms observed in these corpuscles and the accumulation of this insoluble blood pigment in the liver and spleen of those who have suffered repeated attacks of intermittent fever. The enormous loss of red blood corpuscles as a result of such attacks is shown by the anæmic condition of the patient and also by actual enumeration. According to Kelsch, a patient of vigorous constitution in the first four days of a quotidian intermittent fever, or a remittent of first invasion, may suffer a loss of 2,000,000 of red blood corpuscles per cubic millimeter of blood, and in certain cases a loss of 1,000,000 has been verified at the end of twenty-four hours. In cases of intermittent fever having a duration of twenty to thirty days the number of red blood cells may be reduced from the normal, which is about 5,000,000 per cubic millimeter to 1,000,000 or even less. In view of this destruction of the red blood cells and the demonstrated fact that a certain number, at least, are destroyed during the febrile paroxysms by a blood parasite, which invades the cells and grows at the expense of the continued hæmoglobin, it may be thought that the etiological rôle of the parasite should be conceded. But scientific conservatism demands more than this, and the final proof has been afforded by the experiments of Gerhardt and of Marchiafava and Celli—

since confirmed by many others. This proof consists in the experimental inoculation of healthy individuals with blood containing the parasite and the development of a typical attack of periodic fever as a result of such inoculation. Marchiafava and Bignami, in their elaborate article upon 'Malaria,' published in the 'Twentieth Century Practice of Medicine,' say:

"The transmission of the disease occurs equally whether the blood is taken during the apyretic period or during a febrile paroxysm, whether it contains young parasites or those in process of development, or whether it contains sporulation forms. Only the crescent forms, when injected alone, do not transmit the infection, as has been demonstrated by Bastianelli, Bignami and Thayer, and as can be readily understood when we remember the biological significance of these forms.

"In order that the disease be reproduced in the inoculated subject it is not necessary to inject the malarial blood into a vein of the recipient, as has been done in most of the experiments; a subcutaneous injection is all-sufficient. Nor is it necessary to inject several cubic centimeters, as was done especially in the earlier experiments; a fraction of a cubic centimeter will suffice and even less than one drop, as Bignami has shown."

After the inoculation of a healthy individual with blood containing the parasite a period varying from four to twenty-one days elapses before the occurrence of a febrile paroxysm. This is the so-called period of incubation, during which, no doubt, the parasite is undergoing multiplication in the blood of the inoculated individual. The duration of this period depends to some extent upon the quantity of blood used for the inoculation and its richness in parasites. It also depends upon the particular variety of the parasite present, for it has been ascertained that there are at least three distinct varieties of the malarial parasite—one which produces the quartan type of fever, in which there is a paroxysm every third day and in which, in experimental inoculations made, the period of incubation has varied from eleven to eighteen days; in the tertian type, or second day fever, the period of incubation noted has been from nine to twelve days; and in the æstivo-autumnal type the duration has usually not exceeded five days. The parasite associated with each of these types of fever may be recognized by an expert, and there is no longer any doubt that the difference in type is due to the fact that different varieties or 'species' of the malarial parasite exist, each having a different period of development. Blood drawn during a febrile paroxysm shows the parasite in its different stages of intra-corpuscular development. The final result of this development is a segmenting body, having pigment granules at its center, which occupies the greater part of the interior of the red corpuscle. The number of segments into which this body divides differs in the different types of fever, and there are other points of difference by which the several varieties may be distinguished one from the other, but which it is not necessary to mention

at the present time. The important point is that the result of the segmentation of the adult parasites contained in the red corpuscles is the formation of a large number of spore-like bodies, which are set free by the disintegration of the remains of the blood corpuscles and which constitute a new brood of reproductive elements, which in their turn invade healthy blood corpuscles and effect their destruction. This cycle of development, without doubt, accounts for the periodicity of the characteristic febrile paroxysms; and, as stated, the different varieties complete their cycle of development in different periods of time, thus accounting for the recurrence of the paroxysms at intervals of forty-eight hours, in one type of fever and of three days in another type. When a daily paroxysm occurs, this is believed to be due to the alternate development of two groups of parasites of the tertian variety, as it has not been possible to distinguish the parasite found in the blood of persons suffering from a quotidian form of intermittent fever from that of the tertian form. Very often, also, the daily paroxysm occurs on succeeding days at a different hour, while the paroxysm every alternate day is at the same hour, a fact which sustains the view that we have to deal, in such cases, with two broods of the tertian parasite which mature on alternate days. In other cases there may be two distinct paroxysms on the same day, and none on the following day, indicating the presence of two broods of tertian parasites maturing at different hours every second day.

Manson, in his work on tropical diseases, recently published, accounts for the febrile paroxysm as follows:

"In all malarial attacks this periodicity tends to become, and in most attacks actually is, quotidian, tertian, or quartan in type. If we study the parasites associated with these various types we find that they, too, as has been fully described already, have a corresponding periodicity. We have also seen that the commencement of the fever in each case corresponds with the breaking up of the sporulating form of the parasite concerned. This last is an important point; for, doubtless, when this breaking up takes place, besides the pigment set free, other residual matters—not so striking optically, it is true, as the pigment, but none the less real—probably are liberated; a hæmoglobin solvent, for example, as I have suggested. Whether it be this hæmoglobin solvent, or whether it be some other substance, which is the pyrogenetic agent, I believe that some toxin, hitherto enclosed in the body of the parasite, or in the infected corpuscle, escapes into the blood at the moment of sporulation.

"The periodicity of the clinical phenomena is accounted for by the periodicity of the parasite. How are we to account for the periodicity of the parasite? It is true that it has a life of twenty-four hours, or of a multiple of twenty-four hours; but why should the individual parasites of the countless swarm all conspire to mature at or about the same time? That they do so—not perhaps exactly at the same moment, but within a very short time of each other—is a fact, and it is one which can be easily demonstrated. If we wish to see the sporulating forms of the plasmodium in a pure intermittent, it is practically useless to look for them in the blood during the latter stages of fever, or during the interval, or

during any time but just before, during, or soon after rigor. If we wish to see the early and unpigmented forms, we must look for them during the later stage of rigor or the earlier part of the stage of pyrexia. And so with the other stages of the parasite; each has its appropriate relationship to the fever cycle."

There are numerous cases of malarial fever in which there is no distinct intermission and in which the course of the fever is either continued or remittent in character. Fevers of this type usually occur in the late summer or in the autumn (æstivo-autumnal) and are believed to be due to infection by two distinct varieties of the parasite; one, the tertian æstivo-autumnal, causes a fever characterized by a marked rise in the temperature every second day; the other, a fever in which there is a daily elevation of temperature. There are certain peculiarities relating to the intra-corpuscular development of these parasites which enable us to differentiate them from the tertian and quartan parasites of intermittent fever, but a more striking difference to be observed in their life cycle of development in the blood of man is the presence of peculiar crescentic-shaped bodies, which play an important part in their further development in the body of an intermediate host—the mosquito. Associated with these 'crescents' fusiform and ovoid bodies are often seen which are no doubt similar in their origin and function. The crescents are a little longer than the diameter of a red blood corpuscle and are about three times as long as broad. They contain in the central portion grains of pigment (melanin) derived from the hæmoglobin of the infected corpuscle which has been changed into a crescentic body as a result of the development of the malarial parasite in its interior. When a fresh preparation of malarial blood containing these crescents is observed under the microscope, while a majority of them retain the crescentic form, others may be seen, after an interval of ten minutes or more, to change in form, first becoming oval and then round; then, in the interior of these round bodies an active movement of the pigment granules occurs; this is followed by the thrusting forth from the periphery of several filaments—usually four, which have flagella-like movements. These, as a rule, become detached and continue to move rapidly among the blood corpuscles. With reference to the function of these motile filaments, Marchiafava says:

"In these later days there is increasing belief in the theory, which we uphold, that the crescents and the flagellata are sexual forms of the malarial parasite, and that a reproductive act (in which the flagellum represents the male element and an adult crescent the female cell) gives rise to the new being which begins its existence in the tissues of the mosquito."

These crescentic bodies may be found in the blood of man long after all febrile symptoms have disappeared, and it is generally recognized

that they are not directly concerned in the production of the phenomena which constitute a malarial attack and that the administration of quinine has no influence in causing them to disappear from the blood. On the other hand, the febrile phenomena are directly associated with the appearance of the amœboid form of the parasite in the interior of the red blood corpuscles and the administration of suitable doses of quinine has a marked effect in causing these amœba-like micro-organisms to disappear from the blood.

These crescentic bodies are not found in the benign tertian and quartan intermittent fevers, but are characteristic of the malignant forms of malarial infection, including the so-called æstivo-autumnal fever. In these forms of fever they are not seen at the outset of the attack, and they have no direct influence upon the course of the fever. A week usually elapses between the first appearance of the amœboid form of the parasite and that of these crescentic bodies. They are often found in the blood some time after all symptoms of fever have disappeared, and are associated with the malarial cachexia which follows an attack of æstivo-autumnal fever. When blood containing these crescents is ingested by a mosquito of the genus *Anopheles* the following very remarkable transformations occur: Some of the crescents are transformed into hyaline flagellate bodies having active movements; others are changed into granular spheres. The flagella break away from the hyaline bodies and, approaching the granular spheres, appear to seek energetically to enter these bodies. A minute papilla is given off from the surface of the sphere, seeming to be projected to meet the attacking flagellum. At this point, one of the flagella succeeds in entering the sphere, causing an active movement of its contents for a brief time, after which the flagella disappear from view, and the contents become quiescent. This is no doubt an act of impregnation. After a time the impregnated granular sphere alters its shape, becoming oval, and later vermicular in form. The pigment granules are now seen at the posterior part of this body, which, after the changes mentioned, exhibits active movements. It is believed that this motile vermicular body penetrates the wall of the mosquito's stomach. Here it grows rapidly and, after a few days, may be seen projecting from the surface as a spherical mass. In the meantime the contents are transformed into spindle-shaped bodies (sporozoites) which are subsequently set free by the rupture of the capsule of the mother cell. According to Manson, these spindle-shaped bodies pass from the body cavity of the mosquito, probably by way of the blood, to the three-lobed veneno-salivary glands, lying on each side of the fore part of the thorax of the insect. "These glands communicate with the base of the mosquito's proboscis by means of a long duct along the radicles of which the clear, plump cells of the gland are arranged. The sporozoites can be readily recognized in many, though not in all, of the

cells, especially in those of the middle lobe, and also free in the ducts. So numerous are they in some of the cells that the appearance they present is suggestive of a bacillus-laden lepra-cell."

The hypothesis that malarial infection results from the bites of mosquitoes was advanced and ably supported by Dr. A. F. A. King, of Washington, D. C., in a paper read before the Philosophical Society on February 10, 1883, and published in the POPULAR SCIENCE MONTHLY in September of the same year. In 1894, Manson supported the same hypothesis in a paper published in the 'British Medical Journal' (December 8), and the following year (1895) Ross made the important discovery that when blood containing the crescentic bodies was ingested by the mosquito, these crescents rapidly underwent changes similar to those heretofore described, resulting in the formation of motile filaments, which become detached from the parent body and continue to exhibit active movements. In 1897, Ross ascertained, further, that when blood containing crescents was fed to a particular species of mosquito, living pigmented parasites could be found in the stomach walls of the insect. Continuing his researches with a parasite of the same class which is found in birds, and in which the mosquito also serves as an intermediate host, Ross found that this parasite enters the stomach wall of the insect, and, as a result of its development in that locality, forms reproductive bodies (sporozoites), which subsequently find their way to the veneno-salivary glands of the insect which is now capable of infecting other birds of the same species as that from which the blood was obtained in the first instance. Ross further showed that the mosquito which served as an intermediate host for this parasite could not transmit the malarial parasite of man or another similar parasite of birds (halteridium). These discoveries of Ross have been confirmed by Grassi, Koch and others, and it has been shown that the mosquitoes which serve as intermediate host for the malarial parasites of man belong to the genus *Anopheles* and especially to the species known as *Anopheles claviger*.

The question whether mosquitoes infected with the malarial parasite invariably become infected as a result of the ingestion of human blood containing this parasite has not been settled in a definite manner, but certain facts indicate that this is not the case. Thus there are localities noted for being extremely dangerous on account of the malarial fevers contracted by those who visit them, which on this very account are rarely visited by man. Yet there must be a great abundance of infected mosquitoes in these localities, and especially in low, swampy regions in the tropics. If man and the mosquitoes are alone concerned in the propagation of this parasite, how shall we account for the abundance of infected mosquitoes in uninhabited marshes? It appears probable that some other vertebrate animal serves in place of man to maintain the life

cycle of the parasite, or that it may be propagated through successive generations of mosquitoes.

It is well known that persons engaged in digging canals, railroad cuts, etc., in malarious regions are especially liable to be attacked with one or the other of the forms of malarial fever. This may be due to the fact that the digging operations result in the formation of little pools suitable for the development of the eggs of *Anopheles*, but another explanation has been offered. Ross and others have found in infected mosquitoes certain bodies, described by Ross as 'black spores,' which resist decomposition and which may be resting spores capable of retaining their vitality for a long time. The suggestion is that these 'black spores' or other encysted reproductive bodies may have been deposited in the soil by mosquitoes long since defunct 'and that in moving the soil these dormant parasites are set at liberty and so in air, in water or otherwise, gain access to the workmen engaged' (Manson). This hypothesis is not supported by recent observations, which indicate that infection in man occurs only as a result of inoculation through the bite of an infected mosquito. The question is whether malarial fevers can be contracted in marshy localities independently of the mosquito, which has been demonstrated to be an intermediate host of the malarial parasite? Is this parasite present in the air or water in such localities as well as in the bodies of infected mosquitoes? Its presence has never been demonstrated by the microscope; but this fact has little value in view of the great variety of micro-organisms present in marsh water or suspended in the air everywhere near the surface of the ground, and the difficulty of recognizing the elementary reproductive bodies by which the various species are maintained through successive generations. It would appear that a crucial experiment for the determination of this question would be to expose healthy individuals in a malarious region and to exclude the mosquito by some appropriate means. This experiment has been made during the past summer and the result, up to the present time, has been reported by Manson in the London 'Lancet' of September 29. Five healthy individuals have lived in a hut on the Roman Campagna since early in the month of July. They have been protected against mosquito bites by mosquito-netting screens in the doors and windows and by mosquito bars over the beds. They go about freely during the daytime, but remain in their protected hut from sunset to sunrise. At the time Manson made his report all these individuals remained in perfect health. It has long been known that laborers could come from the villages in the mountainous regions near the Roman Campagna and work during the day, returning to their homes at night, without great danger of contracting the fever, while those who remained on the Campagna at night ran great risk of falling sick with fever, as a result of 'exposure to the night air.' What has already been said makes it appear extremely probable

that the 'night air,' *per se*, is no more dangerous than the day air, but that the real danger consists in the presence of infected mosquitoes of a species which seeks its food at night. As pointed out by King, in his paper already referred to, it has repeatedly been claimed by travelers in malarious regions that sleeping under a mosquito bar is an effectual method of prophylaxis against intermittent fevers.

That malarial fevers may be transmitted by mosquitoes of the genus *Anopheles* was first demonstrated by the Italian physician Bignami, whose experiments were made in the Santo Spirito Hospital in Rome. The subjects of the experiment, with their full consent, were placed in a suitable room and exposed to the bites of mosquitoes brought from Maccarese, 'a marshy place with an evil but deserved reputation for the intensity of its fevers.' It has been objected to these experiments that they were made in Rome, at a season of the year when malarial fevers prevail to a greater or less extent in that city, but Marchiafava and Bignami say:

"It is well known to all physicians here that, although there are some centers of malaria in certain portions of the suburbs, the city proper is entirely free from malaria, as long experience has demonstrated, and at no season of the year does one acquire the disease in Rome."

In view of the objection made, a crucial experiment has recently been made in the city of London. The result is reported by Manson, as follows:

"Mosquitoes infected with the parasite of benign tertian malarial fever were sent from Rome to England, and were allowed to feed upon the blood of a perfectly healthy individual (Dr. Manson's son, who had never had malarial disease). Forty mosquitoes, in all, were allowed to bite him between August 29 and September 12. On September 14 he had a rise of temperature, with headache and slight chilliness, but no organisms were found in his blood. A febrile paroxysm occurred daily thereafter, but the parasites did not appear in the blood until September 17, when large numbers of typical tertian parasites were found. They soon disappeared under the influence of quinine."*

We have still to consider the question of the transmission of malarial fevers by the ingestion of water from malarious localities. Numerous medical authors have recorded facts which they deemed convincing as showing that malarial fevers may be contracted in this way. I have long been of the opinion that while the observed facts may, for the most part, be authentic, the inference is based upon a mistake in diagnosis. That, in truth, the fevers which can justly be ascribed to the ingestion of a contaminated water supply are not true malarial fevers—*i. e.*, they are not due to the presence of the malarial parasite in the blood. This view was sustained by me in my work on 'Malaria and Malarial Diseases,'

* Quoted from an editorial in the 'New York Medical Journal' of October 20, 1900.

published in 1883. The fevers supposed to have been contracted in this way are, as a rule, continued or remittent in character and they are known under a variety of names. Thus we have 'Roman fever,' 'Naples fever,' 'Remittent fever,' 'Mountain fever,' 'Typho-malarial fever,' etc. The leading physicians and pathologists, in regions where these fevers prevail, are now convinced that they are not malarial fevers, but are simply more or less typical varieties of typhoid fever—a disease due to a specific bacillus and which is commonly contracted as a result of the ingestion of contaminated water or food. The error in diagnosis, upon which the inference has been based that malarial fevers may be contracted through drinking water, has been widespread, in this country, in Europe and in the British possessions in India. It vitiated our medical statistics of the Civil War and of the recent war with Spain. In my work already referred to, I say:

"Probably one of the most common mistakes in diagnosis, made in all parts of the world where malarial and enteric fevers are endemic, is that of calling an attack of fever, belonging to the last mentioned category, malarial remittent. This arises from the difficulties attending a differential diagnosis at the outset, and from the fact that having once made a diagnosis of malarial fever, the physician, even if convinced later that a mistake has been made, does not always feel willing to confess it. The case, therefore, appears in the mortality returns, if it prove fatal, or in the statistical reports of disease, if made by an army or navy surgeon, as at first diagnosed."

I have already mentioned the fact that Marchiafava denies that malarial fevers prevail in the city of Rome, yet every one knows how frequently travelers contract the so-called 'Roman fever' as a result of a temporary residence in that city. In our own cities numerous cases of so-called 'remittent' or 'typho-malarial' fevers are reported in localities where typical malarial fevers (intermittents) are unknown, and at seasons of the year when these fevers do not prevail even in the marshy regions where they are of annual occurrence—during the mosquito season. Malarial fevers may, of course, occur in cities as a result of exposure elsewhere to the bites of infected mosquitoes of the genus *Anopheles*, either as primary attacks or as a relapse, or in urban localities in the vicinity of marshy places or pools of water suitable as breeding places for *Anopheles*. But when a previously healthy individual, living in a well-paved city, in a locality remote from all swampy places is taken sick with a 'remittent fever,' and especially when the attack occurs during the winter months, it is pretty safe to say that he is not suffering from malarial infection, and the chances are greatly in favor of the view that he has typhoid fever. It must be remembered that a remittent or intermittent course is not peculiar to malarial fevers. Typhoid commonly presents a more or less remittent character, especially at the outset of an attack; the hectic fever of tuberculosis is intermittent in character.

The formation of an abscess, an attack of tonsilitis, etc., are usually attended by chills and fever, which may recur at more or less regular intervals. Indeed, in certain cases of pyæmia the febrile phenomena are so similar to those of a malarial attack that a mistake in diagnosis is no unusual occurrence. Finally, I may say that it is the fashion with many persons and with some physicians to ascribe a variety of symptoms, due to various causes, to 'malaria' and to prescribe quinine as a general panacea. Thus a gentleman who has been at the club until one or two o'clock at night and has smoked half a dozen cigars—not to mention beer and cheese sandwiches as possible factors—reports to his doctor the next morning with a dull headache, a furred tongue and a loss of appetite which he is unable to account for except upon the supposition that he has 'malaria.' Again the symptoms arising from indigestion, from crowd-poisoning, from sewer-gas-poisoning, from ptomaine-poisoning (auto-infection), etc., are often ascribed to 'malaria' and quinine is prescribed, frequently with more or less benefit, for the usefulness of this drug is not limited to its specific action in the destruction of the malarial parasite.

As stated at the outset, it is evident, in the present state of our knowledge, that the term 'malaria' is a misnomer, either as applied to the cause of the periodic fevers or as used to designate this class of fevers. It would be more logical to use the name plasmodium fever and to speak of a plasmodium intermittent or remittent, rather than of a malarial intermittent. But it will, no doubt, be difficult to displace a term which has been so long in use, which up to the present time has had the sanction of the medical profession, and which expresses the popular idea as to the origin of that class of fevers which we now know to be due to a blood-parasite, introduced through the agency of mosquitoes of the genus *Anopheles*.

A STUDY OF BRITISH GENIUS.

By HAVELOCK ELLIS.

1. INTRODUCTORY.

UNTIL now it has not been possible to obtain any comprehensive view of the men and women who have chiefly built up English civilization. It has not, therefore, been possible to study their personal characteristics as a group. The sixty-three volumes of the 'Dictionary of National Biography,' of which the last has been lately issued, have for the first time enabled us to construct an authoritative and well-balanced scheme of the persons of illustrious genius, in every department, who have appeared in the British Isles from the beginning of history down to the end of the nineteenth century; and, with a certain amount of labor, it enables us to sum up their main traits. It has seemed to me worth while—both for the sake of ascertaining the composition of those elements of intellectual ability which Great Britain has contributed to the world, and also as a study of the nature of genius generally—to utilize the 'Dictionary' to work out these results. I propose to present here some of the main conclusions which emerge from such a study.

The 'Dictionary' contains some record—from a few lines to several dozen pages—of some thirty thousand persons. Now, this is an impracticable and undesirable number to deal with—impracticable because, regarding a large proportion of these persons, very little is here recorded or is even known; undesirable because it must be admitted that the majority, though persons of a certain note in their own day or their own circle, cannot be said to have made any remarkable contribution to civilization or to have displayed any very transcendent degree of native ability. My first task, therefore, was to ascertain a principle of selection in accordance with which the persons of relatively less distinguished ability and achievement might be eliminated. At the outset one class of individuals, it was fairly obvious, should be omitted altogether in the construction of any group in which the qualities of native intellectual ability are essential—I mean royalty, and members of the royal family, as well as the hereditary nobility. Those eminent persons, the sons of commoners, who have founded noble families, are, of course, not excluded by this rule, according to which any eminent person whose father, at the time of his birth, had attained the rank of baronet or any higher rank, is necessarily excluded from my list. Certainly the son of a king or a peer may possess a

high degree of native ability, but it is practically impossible to estimate how far that ability would have carried him had he been the son of an ordinary citizen; it might be maintained that a successful merchant, ship-owner, schoolmaster or tradesman requires as much sagacity and mental alertness as even the most successful sovereign; by eliminating those individuals in whom the accident of birth counts for so much, we put this insoluble question out of court. I am surprised to find how few persons of obviously preeminent ability are excluded by this rule, and how many whom, at first, one would imagine it excludes, it really allows to pass, especially in the case of sons born before the father was created a peer. In order to avoid any scandalous omissions, I have thought it well to rule in all those sons of peers whose ability has clearly been of a kind which could not be aided by position and influence; thus I have included the third Earl of Shaftesbury, for it cannot be held that the possession of an earldom tends to aid a man in becoming a philosopher. It has, however, very rarely indeed been necessary to accord this privilege; I have always refrained from according it in the case of soldiers and statesmen.

Having eliminated those whose position in the world has clearly been influenced by the accident of birth, it remained to eliminate those whose place in the world, as well as in the 'Dictionary,' was comparatively small. After some consideration I decided that, generally speaking, those persons to whom less than three pages were allotted were evidently not regarded by the editors, and could scarcely be generally regarded, as of the first rank of eminence. Accordingly, I excluded all those individuals to whom less than that amount of space was devoted. When this was done, however, I found it necessary to go through the 'Dictionary' again, treating this rule in a somewhat more liberal manner. I had so far obtained some 700 names, but I had excluded many persons of undoubtedly very eminent ability and achievement; Hutton, the geologist, and Jane Austen, the novelist, for instance, could scarcely be omitted from a study of British genius. It was evident that persons with eventful lives had a better chance of occupying much space than other persons of equal ability with uneventful lives. Moreover, I found that a somewhat rigid adherence to the rule I had laid down had sometimes resulted in groups that were too small and too ill-balanced to be useful for study. In the case of musical composers, for instance, while those of recent times, of whom much is known, were dealt with at length, the earlier musicians, of whom little is known, though their eminence is much greater, were excluded from my list. On the other hand, a certain number of persons had been included because, though of quite ordinary ability (like Bradshaw, the regicide), they happened by accident to have played a considerable part in history. In going through the

'Dictionary' a second time, therefore, I modified my list in accordance with a new rule, to the effect that biographies occupying less than three pages might be included if the writers seemed to consider that their subjects had shown intellectual ability of a high order, and that those occupying more space might be excluded if the writers considered that their subjects displayed no high intellectual ability. At the same time, I eliminated those persons who rank chiefly as villains (like Titus Oates), and have little claim to the possession of any eminent degree of intellectual ability. I have also felt compelled to exclude women (like Lady Hamilton) whose fame is not due to intellectual ability, but to beauty and to connection with eminent persons.

So far as possible, it will be seen, I have sought to subordinate my own private judgment in making the selection. It has been my object to place the list, so far as possible, on an objective basis. At the same time, it is evident that, while I only reserved to myself a casting vote on doubtful points, there is necessarily a certain proportion of cases where this personal vote had to be given. A purely mechanical method of making selections would necessarily lead to various absurdities, and all that I can claim is that the principles of selection I have adopted have involved a minimum of interference on my part. It is certainly true that, even after much consideration and repeated revision, I remain myself still in doubt regarding a certain proportion of people included in my list and a certain proportion omitted. However often I went through the 'Dictionary,' I know that I should each time make a few trifling readjustments, and any one else who took the trouble to go over the ground I have traversed would likewise wish to make readjustments. But I am convinced that if my principles of selection are accepted, the margin for such readjustment is narrow.

I must here remark that a slightly lower standard of ability has been demanded from the women selected than from the men. It was not my desire that this should be so, and in the first list the same standard was demanded from women as from men. But it soon became clear that this was not practicable. On account of the greater rarity of intellectual ability in women, they have often played a large part in the world on the strength of achievements which would not have allowed a man to play a similarly large part. It seemed, again, impossible to exclude various women of powerful and influential personality, though their achievements were not always considerable; I allude to such persons as Hannah More and Mrs. Montague. Even Mrs. Somerville, the only feminine representative of science in my list, could scarcely be included were she not a woman, for she was little more than the accomplished popularizer of scientific results. In one department, and one only, the women seem to be little, if at all, inferior to the men in ability; that is in acting.

Putting aside the women for the moment, we find that Great Britain has produced no fewer than 859 men of a high degree of intellectual eminence. These I classify, according to the direction of their activities, as follows: Actors, 23; Artists (painters, sculptors, architects), 69; Business Men, 3; Divines, 128; Doctors, 7; Lawyers, 35; Men of Letters, 150; Men of Science (and inventors), 94; Musical Composers, 14; Philanthropists, 4; Philosophers, 27; Poets, 98; Politicians (statesmen, agitators, administrators, etc.), 113; Sailors, 29; Scholars, 40; Schoolmasters, 4; Soldiers, 46; Travelers and Explorers, 9.

It is necessary to make certain remarks concerning this classification. In the first place, there is some amount of duplication, owing to one man having sometimes distinguished himself in more than one field. This I have sought to minimize by placing a man only in those departments in which he really reached a high degree of eminence; thus many individuals belonging to the church or the law appear in my lists only as Politicians, Philosophers or Men of Letters, and not as Divines or Lawyers. It must be admitted, however, that, in a large proportion of cases, the question of classification and of duplication remains difficult and doubtful. The longest and most miscellaneous group is that of Men of Letters. It would have been possible to include the Poets also in this group, and in some cases (especially in regard to some of the Elizabethan dramatists) it has been difficult to decide into which group a writer should fall; but, on the whole, the Poets were too large, important and homogeneous a group to be merged into the miscellaneous body of Men of Letters. The smallness of the group of Business Men will probably attract attention. It would, indeed, be possible to enlarge the group somewhat, especially by including various prosperous publishers and newspaper proprietors; but it scarcely appeared that the biographers of these worthies regarded them as persons of extraordinary intellectual ability, and it was also notable that in many cases they owed much to birth and circumstances; in any case, the group would still remain small. It may seem strange that 'a nation of shopkeepers' should have produced so few merchant princes entitled to figure brilliantly in this 'Dictionary.' The real reason seems to be that a man of marked ability is not content to achieve success in business only; he uses his business capacity merely as an instrument for attaining further ends, to become free to devote himself to literary or scientific aims, and especially to obtain an entry into politics; business success is thus subordinated to success in other fields. It must be added that, while many inventors have used their scientific activity to build up large businesses, their claim to recognition in the 'Dictionary' remains that of men of science. Another unexpectedly small group is that of Doctors. Here, again, it would have been possible to enlarge the group somewhat by including a certain number of

medical men, who are not, however, considered by their biographers to have really attained a durable reputation. Just as a really able business man is not satisfied with business success, so a really able doctor is not satisfied with professional success, but seeks a higher success, especially in science. A number of eminent men in science, letters and philosophy have been doctors, but it has not been in medical practice that their reputations have been made. I have no comments to make on the other groups, which, in all cases, I believe, fairly correspond to the real distribution of high ability. The group of Divines may seem large, but it certainly appears that religion has offered, in the past, if not in the present, a peculiarly favorable field for the development of mental ability.

There are 43 eminent women, the proportion to eminent men being only about 1 to 20, although, as I have already pointed out, a somewhat lower standard of intellectual ability seems here to be demanded in order to attain eminence. The eminent women fall into the following groups: Actresses, 13; Women of Letters, 23; Women of Science, 1; Philanthropists, 1; Poets, 5. It will be noticed that women have only attained eminence in five out of the eighteen departments, although, even allowing for legal and other disabilities, they have been free to attain eminence in at least twelve departments.

Having now explained how these lists have been obtained, it may be well at this stage to enumerate the individuals who thus appear entitled to rank as the preeminent men and women of genius produced by the British Isles. Names appearing in more than one group are marked by an asterisk. It has not been thought necessary to distinguish the very numerous cases in which individuals of the same name appear in different groups, since no confusion should thus be caused.

Actors.—Betterton, Booth, Burbage, Cibber, Cooke, Elliston, Foote, Garrick, Kean, Kemble, King, Lewis, Liston, Macklin, Macready, C. Mathews, C. J. Mathews, Palmer, Phelps, Quin, Webster, Wilks, Woodward.

Artists.—Adam, Banks, C. Barry, J. Barry, Bewick, Blake,* Bonington, Browne, Cattermole, Chantrey, Cockerell, Constable, Cooper, Copley, Cotman, Cox, Cozens, Crome, Cruikshank, Danby, Dawson, Dobson, Doyle, Dyce, Eastlake, Etty, Flaxman, Gainsborough, Gibson, Girtin, Gillray, Haydon, Hogarth, Holl, Inigo Jones, Keene, Landseer, Lawrence, Lewis, Linnell, Leech, Maclise, Morland, Mulready, Northcote, Opie, Phillip, Pugin, Raeburn, Reynolds, Romney, Rossetti,* Rowlandson, Sandby, D. Scott, G. Scott, Stevens, Stothard, Street, Stubbs, Turner, Vanbrugh,* Varley, Walker, Wilkie, Wilson, Woolner, Wren, Wright.

Business Men.—Gresham, Paterson, Whittington.

Divines.—Abbot, Adrian IV., Ainsworth, Alesius, Allen, Andrewes,* Atterbury, Bancroft, Barclay, Barrow,* Baxter, Bedell, St. Boniface, Bonner, Bradshaw, Browne, Burges, Burnet,* Butler,* Campion, Candlish, St. Thomas de Cantelupe, Cartwright, Challoner, Chalmers, Chichele, Chillingworth, Clarke, Colenso, St. Columba, St. Columban, Cooke, Cosin, Coverdale, Cranmer, Cudworth, St. Cuthbert, Dolben, Doddridge, Donne,* Duff, St. Dunstan, St. Edmund, Emlyn, Erskine, Faber, Ferrar, Fox, Foxe,* Fuller, Garnett, Henderson,* Heylin, Hoadley, Hook, Hooker,

Irving, Jewel, Keble, Ken, King, Knox,* Langton,* Lardner, Latimer, Laud, Law, Leighton, Leslie, Liddon, Lightfoot, Lloyd, Loftus, Manning, Marsh, Marshall, Maurice, Melville, Middleton, Milner, Moffat, Montague, Naylor, Newman, Nowell, Owen, Paley,* Parker, Parsons, St. Patrick, Payne, Pearson,* Pecock, Peirce, Penry, Perkins, Peters, Powell, Preston, Pusey, Ridley, Sancroft, Sharp, Sheldon, Stanley,* Tait, Taylor, Tillotson, Tyndale,* Walsh, Warham, C. Wesley, J. Wesley, Blanco White, Whitefield, Whitehead, Whitgift, Wilberforce, St. Wilfrid, Willett, D. Williams, R. Williams, Wilson, Wiseman, Wishart, Wordsworth, St. Wulfstan, Wycliffe.*

Doctors.—Caius,* Linacre,* Mead, Pott, Sydenham, Cheselden, Cullen.

Lawyers.—Abinger, Ashburton, Austin, Blackstone, Cairns, Camden, Campbell, Clare, Cockburn, Coke, Curran, Denman, Eldon, Ellenborough, Fortescue, Haddington, Hale, Hardwicke, Kenyon, Littleton, Lyndhurst, Macclesfield, Maine, More,* Noye, St. John, Selbourne, Selden, Somers, Stair, Stephen, Stowell, Thurlow, Westbury, Williams.

Men of Letters.—Addison, Alcuin, Ascham, Bagehot, Banim, Barclay, Beckford, Bede, Borrow, Boswell, Browne, Buchanan,* Buckle, Bunyan, Burton, Calamy, Camden, Carleton, Carlile, Carlyle, Cibber,* Cobbett, Collier, Colman, Congreve, Cotton, Cowley,* Croker, D'Avenant, Day, Defoe, Dekker, Dempster, De Quincey, D'Ewes, Dickens, Digby, Dugdale, Elyot, Etheridge, Fanshawe, Farquhar, Fielding, Foxe, Francis, Galt, Geoffrey of Monmouth, Gibbon, Gifford, Giraldus, Goldsmith, Green, Grote, Hall, Hallam, Halliwell-Phillips, Hamilton, Harrington, Hazlitt, Herbert, Holcroft, Hood, Hook, Howell, Hume,* Hunt, Jeffrey, Jerrold, Johnson, Jonson, Kemble, Kennett, Killigrew, Kingsley, Knowles, Lamb, Landor, Lee, Leland, L'Estrange, Lever, Lewes, Lillo, Lingard, Lockhart, Lodge, Lover, Lyly, Lytton, Macaulay, Mackenzie, Maginn, Malone, Marryatt, Map, Milman, More,* Nash, Oliphant, Oldys, Paine, Paris, Perry, Pater, Pepys, Prynne, Raleigh,* Reade, Richardson, Ritson, Robertson, Roscoe, Scott, Seeley, Sheil, Sheridan,* Smollett, Southey, Sprat, Sidney Smith, Stanley,* Steele, Sterne, Steevens, Stevenson, Stow, Swift, Symonds, H. Taylor, W. Taylor, Temple,* Thackeray, Thirlwall, Trelawney, Trollope, Tyndale,* Udall, Urquhart, Vanbrugh,* Wakley,* Walton, Warburton, Warton, Whately, William of Malmesbury, William of Newburgh, Williams, Wilson, Wolcot, Wright, Wycherley.

Men of Science.—Arkwright, Babbage, R. Bacon,* Baily, Balfour, Banks, Barrow,* Baskerville, Bell, Bentham, Black, Boyle, Bradley, Brewster, Carpenter, Carrington, Cavendish, Caxton, Clifford, Colby, Cotes, Dalton, C. Darwin, E. Darwin, Davy, Dee, De Morgan, Drummond, Falconer, Faraday, Ferguson, Flamsteed, Flinders,* E. Forbes, J. D. Forbes, Gilbert, Glisson, Grew, Hales, Halley, Hamilton, Harvey, Herschel, Hooker, Horrocks, Hunter, Hutton, Jenner, Jevons, Joule, Knight, Lefroy, Lister, Lyell, Maclaurin, Malthus, Maxwell, Milner, Morland, Murchison, Murdoch, Napier, Newton, Oughtred, Owen, Parkes, Petty, Priestley, Ray, Sabine,* Sadler, Sedgwick, Sinclair, A. Smith, H. J. Smith, R. A. Smith, W. Smith, Stephenson, Sturgeon, Telford, Trevitheck, Tyndall, Wallis, Ward, Watson, Wedgwood, Whewell, White, Whitworth, Wilkins, Williamson, Wollaston, A. Young, T. Young,

Musical Composers.—Arne, Balfe, Bennett, Blow, Boyce, Byrd, Dowland, Gauntlett, Gibbons, Lawes, Macfarren, Purcell, Tallis, Tye.

Philanthropists.—Howard, Oglethorpe, Owen, Wakley.*

Philosophers.—Bacon, Roger Bacon,* Bentham, Berkeley, Bradwardine, Butler,* Duns, Erigena, Godwin, Hamilton, Hartley, Hinton, Hobbes, Hume,* Locke, Mackintosh, J. Mill, J. S. Mill, Ockham, Paley, Price, Reid, Shaftesbury, Stewart, Toland, Ward, Wycliffe.*

Poets.—Barbour, Barclay, Barham, Barnfield, Beaumont, Beddoes, Blake,* Bre-

ton, Browne, Bruce, Burns, Butler, Byron, Caedmon, Campbell, Campion, Chapman, Chatterton, Chaucer, Churchill, Clare, Clough, S. T. Coleridge, H. Coleridge, Collins, Cotton, Cowper, Crabbe, Crashaw, Daniel, Davies, Denham, Dibdin, Dobell, Donne,* Douglas, Drayton, Drummond, Dryden, Dunbar, D'Urfey, Fletcher, Ford, Fergusson, Fitzgerald, Gascoigne, Gay, Gower, Gray, Greene, Herbert, Herrick, J. Heywood, T. Heywood, Hogg, Hood, Keats, Keble, Langland, Lindsay, Lovelace, Lydgate, Marlowe, Marvell, Massinger, Middleton, Milton, Moore, Munday, Norton, Otway, Peele, Pope, Prior, Quarles, Rogers, Rossetti,* Rowe, Savage, Shakespeare, Shelley, Shirley, Sidney,* Skelton, Smart, Southwell, Spenser, Suckling, Tennyson, Thomson, Vaughan, Waller, Watson, Wither, Wordsworth, Wotton, Wyatt, Young.

Politicians.—Arthur, A. Bacon, N. Bacon, Bateman, Bradford, Brooke, Brougham, Burke, Burghley, Burnet,* Cade, Canning, Earl Canning, Carstares, Chatham, Chichester, Clarendon, Clive, Cobbett,* Cobden, Cork, Coutances, O. Cromwell, T. Cromwell, Eliot, Ellenborough, Fawcett, Fletcher, Forster, Fox, Foxe,* Frere, Gardener, Grattan, G. Grenville, W. Grenville, Hampden, Harrington, Hastings, Henderson,* Horner, Hubert Walter, Huskisson, Ireton, Kemp, Kirkcaldy, Knox,* S. Langton, W. Langton, Law, Lawrence, Leslie, Lewis, Lilburne, Lucas, Ludlow, Lytton, Macdonald, Macnaghten, Malcolm, Marten, Melville, Northumberland, O'Connell, Oldcastle, O'Leary, O'Neill, Paget, Parkes, Parnell, Peel, Penn, Pitt, Pownall, Pulteney, Pym, Raffles, Reid,* Roe, Rose, Sacheverell, St. Leger, Shaftesbury, Sherbrooke, Sheil,* Sheridan,* T. Smith,* Stratford de Redcliffe, Stirling, Temple,* Thurloe, Tone, Tooke, Tunstall, Vane, Wallace,* Walpole, Walsingham, Warriston, Waynflete, Wentworth, Whitbread, Whitelocke, Wilberforce, Wilkes, Williamson, Windham, Winthrop, Winwood, Wolsey, Wotton, Wykeham, Wyse.

Sailors.—Anson, Blake, Brooke, Byng, Cavendish, Cook, Dampier, Deane, Drake, Duncan, Exmouth, Flinders,* Franklin, Frobisher, Gilbert, Hawke, Hawkins, Hood, Leake, Nelson, Penn, Popham, Raleigh,* Rodney, Smith, St. Vincent, Trollope, Vernon, Willoughby.

Scholars.—Andrewes,* Adamson, Barrow,* Bentley, Bingham, Boece, Buchanan,* Caius,* Cheke, Colebrooke, Colet, Conington, Crichton, Dodwell, Grocyn, Grosseteste, Hales, Hickes, John of Salisbury, Jones, Lane, Lightfoot, Linacre,* Lowth, Montague, Morton, Palmer, Pattison, Pearson,* Pocock, Porson, Salesbury, Savile, T. Smith, W. R. Smith, Spelman, Thomas, Ussher, Whiston, Wordsworth.

Schoolmasters.—Arnold, Bell, Lancaster, Parr.

Soldiers.—Abercrombie, Cadogan, Campbell, Dundee, Edwardes, Gordon, Hardinge, Havelock, Hawkwood, Jones, Knollys, Lake, Lambert, H. Lawrence, S. Lawrence, Leven, Mackay, Marlborough, Moore, Morgan, Munro, Napier, Neill, Nicholson, Nott, Ochterlony, Oglethorpe,* Outram, Picton, Pollock, Raleigh,* Reid, H. D. Ross, R. Ross, Sabine,* Sale, Sidney,* Smith, Tarleton, F. Vere, H. Vere, Wallace,* Waller, Williams, Wilson, Wolfe.

Travelers.—Barrow, Bowring, Bruce, Chesney, Clapperton, Lander, Livingstone, Park, Speke.

The women fall into the following groups:

Actresses.—Abington, Anne Barry, Elizabeth Barry, Bracegirdle, Cibber, Clive, Jordan, Kelley, Oldfield, O'Neil, Siddons, Woffington, Yates.

Philanthropist.—Fry.

Poets.—Baillie, Browning, Hemans, Landon, Rossetti.

Women of Letters.—Austen, Barbauld Behn, Burney, C. Brontë, E. Brontë,

Centlivre, Cowley, Edgeworth, Eliot, Ferrier, Gaskell, Godwin, Inchbald, Jameson, Martineau, Mitford, Montague, More, Morgan, Newcastle, Opie, Radcliffe.

***Women of Science.*—Somerville.**

It may be asked how these 902 persons of preeminent intellectual ability have been distributed through the course of English history. I find that from the fourth to the eleventh centuries, inclusive, there are only 14 men of sufficient distinction to appear in my lists. From that date onwards (reckoning by the date of birth) we find that the twelfth century yields 10, the thirteenth 9, the fourteenth 16, the fifteenth 31, the sixteenth 156, the seventeenth 182, the eighteenth 352, the nineteenth 132. It is probable that the estimate most nearly corresponds to the actual facts as regards the seventeenth and eighteenth centuries. Before that time our information is usually too scanty, so that many men of notable ability have passed away without record. In the nineteenth century, on the other hand, the material has been too copious, and the national biographers have probably tended to become unduly appreciative of every faint manifestation of intellectual ability. The extraordinary productiveness of the eighteenth century is very remarkable. In order to realize the significance of the facts, however, a century is too long a period. Distributing our persons of genius into half-century periods, I find that the following groups are formed:

1101–1150	1151–1200	1201–1250	1251–1300	1301–1350	1351–1400
4	6	2	7	6	10
1401–1450	**1451–1500**	**1501–1550**	**1551–1600**	**1601–1650**	**1651–1700**
6	25	49	107	107	75
1701–1750	**1751–1800**	**1801–1850**			
129	223	131			

Only one individual belongs to the second half of the nineteenth century. It is scarcely necessary to remark that the record for the first half of the nineteenth century is still incomplete. Taking the experience of the previous century as a basis, it may be estimated that some 40 per cent. at least of the eminent persons belonging to the first half of the nineteenth century are still alive. This would raise that half-century to the first place, but it may be pointed out that the increase on the previous half-century would be small, and also that the result must be discounted by the inevitable tendency to overestimate the men of our own time. When we bear in mind that the activities of the individuals in each of these groups really fall, on the whole, into the succeeding group, certain interesting points are suggested. We note how the waves of Humanism and Reformation, when striking the shores of Britain, have stirred intellectual activity, and have been prolonged and intensified in the delayed English Renaissance. We see how this fermentation has been continued in the political movements

of the middle of the seventeenth century, and we note the influence of the European upheaval at the end of the eighteenth century. The extraordinary outburst of intellect in the second half of that century is accentuated by the fact that, taking into account all entries in the 'Biographical Dictionary,' the gross number of eminent men of the low standard required for inclusion shows little increase in the eighteenth century (5,789, as against 5,674 in the preceding century, is the editor's estimate); the increase of ability is thus in quality rather than in quantity. It is curious to note that, throughout these eight centuries, a marked rise in the level of intellectual ability has very frequently, though not invariably, been preceded by a marked fall. It is also noteworthy that in nearly every century the majority of its great men have been born in the latter half; that is to say, that the beginning of a century tends to be marked by an outburst of genius, which declines through the century. This outburst is very distinct at the beginning of the nineteenth century, and, as we have seen reason to believe, it was probably succeeded by an arrest, if not a decline, in the production of genius. If that is so, we may probably expect a fresh outburst of intellectual ability at the beginning of the twentieth century. It would seem that we are here in the presence of two factors: a spontaneous rhythmical rise and fall in the production of genius, so that a period of what is improperly called 'decadence' is followed by one of expansive activity; and also, at the same time, the stimulating influence of great historical events, calling out latent intellectual energy. These considerations, however, are merely speculative, and it is sufficient to accord them this brief passing notice.

Having thus explained the nature of the data with which we have to deal, and the methods by which it has been obtained, we may now proceed, without further explanations, to investigate it. We have to study the chief characteristics—anthropological and psychological—of the most eminent British men and women of genius (using that word merely to signify high intellectual ability), in so far as these characteristics are revealed by the 'Dictionary of National Biography.'*

* In a certain number of cases I have supplemented or corrected the information derived from the 'Dictionary' by reference to other reliable sources, in many cases of more recent date.

THE WEATHER VS. THE NEWSPAPERS.

By HARVEY MAITLAND WATTS.
THE PHILADELPHIA 'PRESS.'

"APRIL 4, 1668. I did attend the Duke of York and he did carry us to the King's lodgings; but he was asleep in his closet; so we stayed in the green-room; where the Duke of York did tell us what rule he had of knowing the weather; and did now tell us we should have rain before to-morrow (it having been a dry season for some time) and so it did rain all night almost; and pretty rules he hath, and told Brouncker and me some of them, which were such as no reason can readily be given for them."—*Pepys' Diary.*

In 1668 the inquisitive Pepys had warrant for his exclusion of weather lore from the domain of reason, but with three centuries gone all things have changed, save the ready disposition of men of a certain literary bent to cry 'mystery' where there is none, and of all the popular phrases in use to-day, when the weather is up for discussion in the newspapers, none is so abused in the over-using as that which points out that science has 'no reasonable explanation' to offer, and this of phenomena explained in school books!

Indeed, though the secular newspaper is not otherwise given to an observance of Biblical philosophy, no saying is more devoutly believed, no maxim more rigidly accepted as the guiding principle of journalism in its treatment of the weather, than that of the famous text: 'The wind bloweth where it listeth and thou hearest the sound thereof, but canst not tell whence it cometh or whither it goeth.'

The indifference to weather facts is all the more extraordinary, since the weather is not a casual matter, but one of necessitated daily interest to the public, and, consequently, to the newspaper. That the newspaper recognizes this interest, that it caters to it, that it makes a special effort to meet a taste which it, in fact, partly creates, is shown by the extreme industry evinced in the collection, classification and presentation of storm news; in the constant appearance of the 'weather' assignment on the city editor's list, and in a zeal for a weather 'spread,' with a pomp of type and details; unfortunately, however, not according to knowledge, and, so far as the public is concerned, too often making 'confusion worse confounded.'

In view, therefore, of popular interest in the weather, and in view of the great change that has come over the science of the weather in the past twenty-five years, it is as amazing as it is deplorable that such

an indictment of the newspaper treatment of the weather can be made, since; although in this matter the newspaper reflects public ignorance and adds to it, in other lines of endeavor the average newspaper is quick to reflect knowledge and expertness. But with the weather it is otherwise. Instead of informing, most newspapers merely confirm popular error. Although for a generation the main facts of weather drift have been settled beyond dispute, they know nothing of it; they are still in the swaddling clothes of belief, and still accept the concepts of their grandfathers, who swore by the 'Shepherd of Banbury's Rules,' and knew a wet moon when they saw it. As under normal circumstances this profound ignorance would give way slowly to the new science, it is regrettable that on the part of journalism there should be so gross a dereliction, and that at this late day, instead of being the harbinger of the new fact, it should still be the handmaiden of the old obscurantism. If, believing the problem of meteorology to be too difficult to understand, the newspaper would let the weather alone, things might improve. But, unfortunately, the weather will not let the newspaper alone, and so, through government forecast and actual incident and accident, the newspaper must keep pegging away at it, editorially and 'reportorially,' until the present anomalous state of things is developed, for which there is no excuse in the nature of science or in the intelligence of those who 'get out' the modern newspaper. A daily journal is not a technical publication. One does not expect to see worked out in it problems in the differential calculus. One might forgive a casual error in the statement of the formulæ for hydrocarbon compounds, since organic chemistry is not served up as a daily dish, but the persistent indifference to meteorological explanations, within the capacity of a boy of fifteen, is inexcusable, and, unfortunately, as the comments on the Galveston horror show, there is no sign of a change for the better. A few, a very few, newspapers—exceptions but prove the rule—reflect expertness and evince common-sense accuracy, still at the same time losing nothing in the way of presenting the subject in an interesting and attractive manner; but, for the most part, the average newspaper fails in its duty to the public, so far as the weather is concerned, in the four following particulars:

1. By reason of a misapprehension and misrepresentation of the simplest fundamental facts of atmospheric circulation and weather movement, effects being treated as causes, etc.

2. By reason of a constant confusion of terminology and a generally slipshod use of weather terms and facts.

3. By reason of a persistent refusal to recognize much, if any, difference between the scientist and the charlatan, between the expert and the quack; and, in fact, by a disposition—marked in some quarters—to give undue prominence to bogus weather prophets and wonder-

mongers, at the expense of the equipped and reputable students of the subject.

4. By reason of a hypercritical but uninformed attitude toward the daily forecasts of the United States Weather Bureau, by which the work of the Bureau is hampered and its value to the public materially reduced.

Such is the situation. If the apprehension of the simple fundamental facts of the weather—taking the first count in the indictment into consideration—were difficult, if the problems were beyond the ability of the man in the street, one would excuse the newspaper and quash the indictment, but the practical questions at issue are as clear as crystal and as simple as A, B, C. There is no dispute among observers as to the fundamental facts, and the surface phenomena themselves are as regular as the progress of the sun from tropic to tropic. The abstract and controversial discussion as to final causes which occupies certain meteorologists is not germane, so far as the treatment of the daily weather goes, and it is the newspaper, not the weather men, who cannot tell a meteorological 'hawk from a hand-saw.'

Because a Dolbear, a Trowbridge and a Lodge may not agree on the ultimate expression for electric energy does not prevent a citizen from distinguishing between arc and incandescent lights, or between a trolley car and a call bell. And so it is with the simple weather facts. The synthesis of American weather, which can be given in two sentences, is within the understanding of any one, for American weather is the resultant of a west to east drift in the general circumpolar circulation of the north temperate zone, which drift is broken up into two great eddies, and only two, the cyclonic and the anti-cyclonic; the former, the cyclonic, the center of general storm phenomena, and the condition and cause of local storm disturbances (tornadoes, squalls, thunderstorms, etc., as local conditions and the seasons determine); the latter, the anti-cyclonic, the center of clear weather phenomena. Into this circumpolar system intrude the tropical anti-cyclone and the tropical cyclone, and play their part in the proper season and region. That is all.

The great circumpolar drift moves in ceaseless round from the Pacific to the Mississippi Valley, from the Mississippi Valley to the Atlantic, from the Atlantic to Europe, to Asia, to the Pacific, and back again. In it appear the two great atmospheric eddies, oftentimes over a thousand miles in diameter, and covering 1,000,000 square miles of the earth's surface. These two type eddies, the cyclonic and the anti-cyclonic, are the real distributers of the weather, as we know it. They can be seen to shift as a whole from west to east, not necessarily along a straight line, however, for they have a way of bellying down, or sidling from the northwest to the southeast, and from the southwest to the northeast, or from all points in the west between

north and south to all points in the east between north and south, making all sorts of combinations, accelerating in speed, slowing up, sometimes standing still seemingly, but yet progressing surely, certainly, inevitably to the east.

The anti-cyclone, judging it wholly from its invariable surface effects, which can be seen day after day on the United States Weather Bureau's daily maps, is essentially a down-draught eddy or center of dispersion for the winds; an area where the barometric pressure is above the normal (Chart No. 1). The cyclone, also invariably, so far as the surface levels of the atmosphere go, is an up-draught eddy, a center of wind concentration; an area where the barometric pressure is below the normal (Chart No. 2). When it is remembered that the winds circulate outward from the high pressure center of an anti-cyclone spirally, from left to right, clockwise, while the winds move into the low pressure of a cyclone spirally, from right to left, counter clockwise, some idea of the simplicity of weather causation is gained. Remembering also that, by reason of the descent of relatively cool, dry air and its dispersion, the polar anti-cyclone is the cause of clear and cool weather phenomena, while by reason of the rushing in of warm, moist air on one side, its expansion and cooling as it rises, and cool, dry air on the other, the cyclone is the seat of storm phenomena, the first primary lesson in American weather is over.

Through a failure to grasp the greater synthesis of the weather, terminology and local storm differentiation have naturally become hopelessly muddled in the newspapers, though here the difficulty of grasping the facts is even less than in the first issue. The cyclone is the center of rhetorical disturbance, and inky clouds of misuse and abuse gather about it, since, as a parent of storms and as a weather-breeder of no mean type, the cyclone plays the dramatic leading rôle in American meteorology. It is not only itself capable of great development of storm energies in the winter, early spring and late autumn, but in its milder summer moments is particularly likely to be the parent of specific local disturbances. With one of these, the tornado, it is identified popularly by the newspapers, which, in spite of all explanation on the part of the Weather Bureau, have not yet seen the absurdity of applying to a secondary phenomenon, insignificant in size compared with the primary eddy, the name of the general disturbance. The cyclone, sweeping along with warm, moist weather in front, clear and cool weather in its rear, attended by a general rain, and in its sphere of influence covering a dozen States or more, surely may be separated from the local tornadoes, which, though destructive and terrifying, are but mere local incidents in the parent circulation. This is so markedly shown in the weather map of March 27, 1890, that, once seen, it is incomprehensible how error can so hold its own (Chart No. 3).

The simplest study of the invariable facts shows that the tornado is a small eddy, superinduced under favorable meteorological and topographical conditions in the outer circulation (southwest to southeast quadrant) of a general low area disturbance (cyclone). It is of extreme intensity, the rotary motion of its winds around the central core (vortex) being inconceivably swift (100 to 500 and perhaps 1,000 miles an hour), but is limited as to duration—it lasts, at the longest, but a few hours; limited as to the width of path, this may vary from fifty to five hundred yards, one of a mile in width being exceptional, and limited as to the length of track, which if it exceeds 100 miles is unusual. Now, a cyclone is continental in magnitude, and may travel for weeks, going two-thirds of the way around the globe. Just as the cyclone's path is determined by interaction of barometric stresses in the general drift of the whole atmosphere, so the path of tornadoes is determined by the interaction of currents in the cyclonic drift. Individual tornadoes do not cross the country intact, as so many weather quacks prophesy, but the parent cyclone that conditions a number of them in the Western States one day, having traveled further east the next day, if local conditions allow, may superinduce similar local outbursts in the Middle States.

Thunder-storms, as a rule, are familiar enough and definite enough to escape the general muddlement, but even they have not escaped the tendency to 'cyclonize' every weather phenomenon. Hence the old-fashioned thunder-gust, the familiar straight outrush of the thunder squall, sometimes destructive, figures nowadays as a 'cyclone,' a 'tornado,' or mayhap a 'hurricane.' Not only this, but the thunder-storms that occur along the line of change from the warm front of a cyclone to the cooler rear—a cool anti-cyclone following—are accused of causing the anti-cyclone when they are an effect of the advancing anti-cyclone and not its cause, any more than the cow-catcher is the cause of the approach of a train.

Above all, the most extraordinary pother and confusion prevail over another storm type, the hurricane or tropical cyclone. Here the newspapers are seconded in their obscurantism by writers of books on the West Indies or the Philippines, all of whom should know better, or could know better if they only so elected. The hurricane—the typhoon is its Asian congener—though the smallest of cyclones, since its diameter usually ranges from 100 to 500 miles, is easily differentiated from the biggest tornado, since the latter's diameter at the greatest barely reaches one mile. As the tornado in its narrow swath kills tens and hundreds, so the hurricane, with vast areas of sea and land swept by the besom of its great winds and washed by its tremendous storm wave, runs the death total up to the hundreds and thousands. The hurricane does not originate in the circumpolar drift, but is a

cyclonic whirl developed on the periphery of the great North Atlantic anti-cyclone. It is a tropical intruder, the only general storm disturbance the tropical circulation gives us. It is no new type, but simply one of the two great eddies known to the general atmospheric circulation the world over. As it is a concentrated cyclone, the winds blow in and about its central vortex with a velocity that may easily reach 100 miles an hour, while velocities of sixty and seventy miles an hour are not uncommon at great distances—500 miles or so—from the center. It is the most violent tempest the newspapers are called upon to chronicle, but its characteristics are so invariable, its paths so well known—determined largely by the position of the North Atlantic anti-cyclone in relation to the continental anti-cyclones—that it is surprising to witness the confusion that marks news and editorial comment when one is at hand. Though every boy has seen a spinning top meandering over the pavement, most newspapers find it difficult to understand the slow forward progressive motion of the whole rotating cyclonic mass on its track. And yet Franklin, over 100 years ago, fathomed the secret of the apparent paradox that the storms that condition our northeast gales actually have their center to the southwest; and Redfield, in 1830-50, taught the American public all about these revolving storms of the Atlantic Ocean, while Piddington, a Briton, in 1848, in his 'Sailor's Horn Book,' made the broad facts plain to the simple-minded, unlearned, every-day navigator, and himself invented* the technical term 'cyclone' specifically to describe the rotary storms, then believed to be peculiar to the tropical oceans. (Chart No. 4).

Hand in hand with misunderstanding and misapprehension of weather phenomena has gone the booming of the weather quack. In some ways this is the most discreditable feature of the newspaper treatment of the weather, since ignorance plus the quack represents a recrudescence of medievalism which would seem incredible, were it not a persistent factor in the 'popular' weather article that is given prominence by leading newspapers, while the waste of telegraphic tolls in sending broadcast the views of some pseudo-scientific zany, whose star for the moment is in the ascendant, is an extravagance which, if spent in the right direction, might save the news-gathering organization money and give it reputation. It is about time the newspapers learned that there are only two classes of weather quacks and wondermongers—those who are greater knaves than fools; those who are greater fools than knaves.. The whole business belongs to the slimy byways of astrology, or represents the fecklessness of those who peddle a quack nostrum composed of one per cent. bogus science to ninety-

* 'The Sailor's Horn Book for the Law of Storms,' by Henry Piddington, London, 1848, page 8.

nine per cent. of piety. And yet these creatures are quoted and exploited, their forecasts are printed in a conspicuous manner and they are encouraged to fleece the ignorant by the authority and circulation given them even by metropolitan journalism.

The spectacle is stultifying, and yet, in the face of this, in the face of the fact that Weather Bureau stations in the great centers of population have been compelled to phrase their forecasts in primer English, because 'cyclone' and 'anti-cyclone' puzzled the newspapers and frightened the people, whose idea had been formed on newspaper interpretation of the forecasts; because 'highs' and 'lows' were deemed too mysterious for comprehension; in face of all this humiliating confusion, the forecasts, if they err, are criticized in a way that not only brings out all the old, but a new ignorance that is as invincible as it is hypercritical, and raises a popular prejudice against the Weather Bureau wholly unwarranted by the facts. Making no quack claims, the Bureau officials are discredited as to short-range or long-range forecasts, while the Wigginses and Devoes take the tripod and scatter storms, floods and dooms, as the irresponsible bad boy splashes water, and are acclaimed therefor. The essential fundamental difficulty of the question of forecasts is—aside from the blank misunderstanding of forecasts that are verified by results—that those who criticize forecasting not only exaggerate the percentage of error, but are wholly oblivious to the fact that forecasting is an art rather than a *science*. The art is based on science, and as the science improves so will the art; but being an art, the personal equation—knowledge of facts being equal—plays a very important part in results. If criticism were directed to any real shortcomings in the Bureau's organization, the Bureau's interests would be promoted; but here, as in other features of weather discussion, the real issues not being apprehended, the discussion is usually pointless and without result. Equipped as the average first-class American newspaper is in plant and staff, alert, keenly anxious to be up to date, impatient of humbug, a unique opportunity is given it by the first year of the new century—always a season of repentance—for that about-face in its treatment of the weather that its past lapses in this respect and the pressing importance of the subject demand.

CHART No. 1.—In this chart, and in all the succeeding ones, the heavy continuous lines are isobars, the lines connecting points that have the same barometric pressures. They thus map out the area in which the barometer may be above or below the normal. The dotted lines are isotherms connecting points that have the same temperatures. On the morning of September 18, 1900, the weather over the central and Atlantic Coast States was dominated by a typical anticyclonic eddy, central over Wisconsin. This anti-cyclone moved into the United States over Montana on the fifteenth, and its drift, being a little south of east, its center passed out to sea off Cape Cod on the twentieth. It was accompanied

for the most part by clear, cool, crisp autumn weather and was the first real break in the reign of warm weather since the cool wave (anti-cyclone) of the last three days of July. As can be seen on the chart, the winds disperse from the center, where the barometer is the highest, and the character of the winds and the local weather it distributes to any one place vary as the center of the anti-cyclone passes north or south of the locality. Since anti-cyclones are the seat and area of high atmospheric pressures, the barometric normal being thirty inches, in the scientific slang of the Weather Bureau they are denominated 'high areas,' or 'highs,' for short. In summer, when coming from the north, the 'highs' are the cause of the cool, and, in the winter, of cold waves, lower or low temperatures invariably accompanying the polar anti-cyclonic eddies. It must be remembered that many anti-cyclones are not so regular in character as the one charted. They are often vague in form and extent—this is also true of cyclonic eddies—

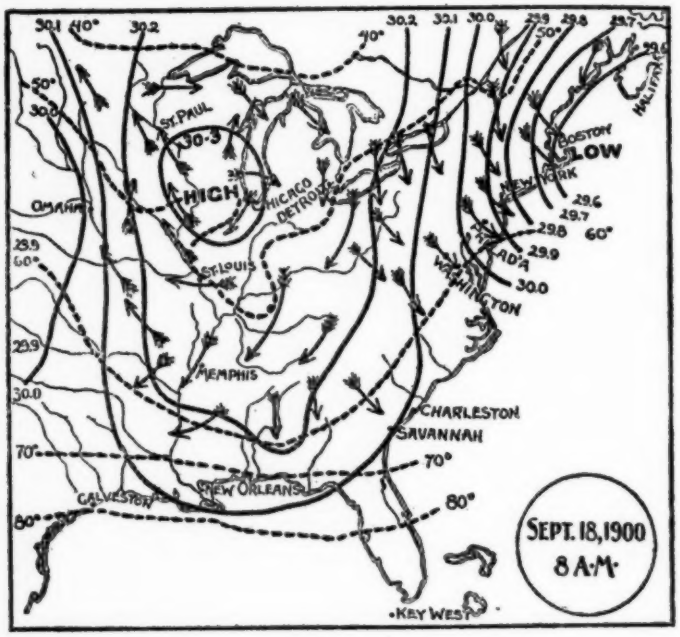

FIG. 1.

and the center may be trough-shaped instead of circular, as was the case with this one by the time it had reached the Atlantic Coast. Certain anti-cyclones that move along the southern circuit or that intrude from the tropical 'high,' as they tend to set up a vigorous circulation from the south to the north, are the predisposing cause of hot waves in summer, and warm waves in winter. The anti-cyclone is the most important eddy in the general circulation, but it was neither discovered nor named till long after the cyclonic circulation had been the subject of an abundant literature.

CHART NO. 2.—The cyclonic eddy is the most interesting weather phenomenon the United States knows. Its sphere of influence is marked by extraordinary contrasts, particularly in between seasons. This typical cyclone, of November 24, 1898, shows how the warm southerly winds, blowing in toward the cyclone in front, push the isotherms to the north and create a warm wave (relatively)

known as the 'sirocco front' (shaded on the chart), while at the same time the cold northerly and westerly winds, blowing south in the rear, carry down the isotherms and mark the extent of the cold wave that follows. Hence around and about an intense early winter cyclone we may have warm, moist rains on the southeast, cool rains, turning to snow, on the east and northeast, with blizzard conditions on the northwestern flank and clear, cold weather on the extreme southwestern, as was the case in this instance. In consequence of this, the possible contrasts through the center of the average early winter cyclone are such as to jump any locality over which it passes from summer (60° to 70°) temperatures to winter (40° to 20°) in a few hours, and it is the passage of a typical cyclone over any given locality that gives the violent changes peculiar to American weather. Wholly independent of its own circulation of winds about its

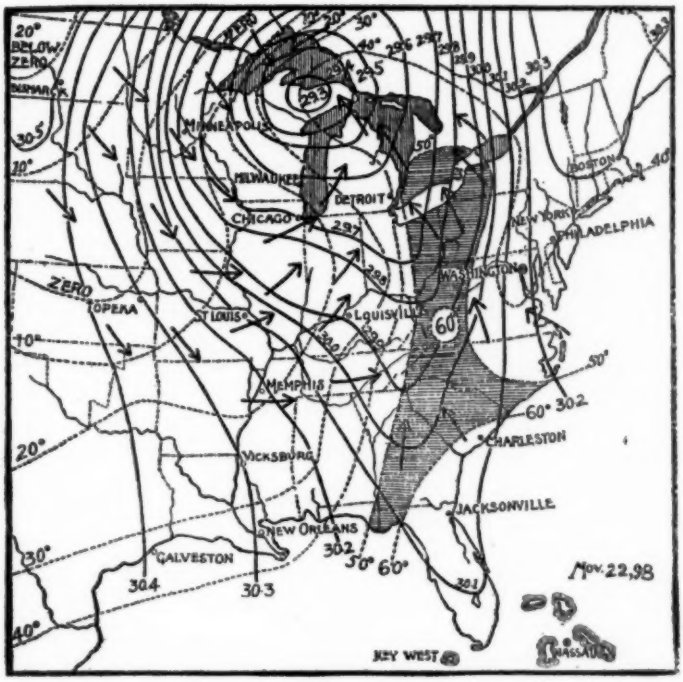

FIG. 2.

center, the cyclone moves forward in the circumpolar drift at the rate of from fifteen to thirty-five miles and more an hour. If it passes north of a place, the locality is affected by its southeasterly, southerly and southwesterly to westerly winds and the weather that belongs to these quadrants. If it moves along a line south of any given place, the locality is affected by its easterly and northeasterly to northerly and northwesterly winds, which make up the coldest and stormiest side of the cyclone. As the barometer at its center is always low, the cyclone is called a 'low area,' or 'low,' for short, and as such appears in Weather Bureau reports. Storm intensity in a cyclone is in due relation to the minima of its own barometric pressures and to the maxima of the anti-cyclone nearest it. All forecasting is based on an effort to balance the probable paths that the cyclones and anti-cyclones will take with respect to the regions east of their point of origin.

CHART No. 3.—The line of tornado frequency naturally moves north with the sun, the tornadoes of winter and spring occurring in the south or border States, while the maximum of tornado frequency for the northern States is in June. Tornadoes are superinduced by unstable conditions of the atmosphere, which are particularly likely to prevail to the southeast and south of a cyclonic center, and the relation of these violent local storms to the great central disturbances is strikingly shown on the United States weather map of March 27, 1890, the day of the Louisville tornado. The parent cyclone was of enormous, though not abnormal, area. It had caused, and was causing, snow and rains from the Rocky Mountain slope to the Hudson Valley, from Arkansas to Minnesota. Its vortex, with a barometric pressure of 29.10 inches—as low as in some of our most destructive tropical cyclones or hurricanes—covering a large part of Illinois,

FIG. 3.

was drawing to it winds from all over the United States, from the Rocky Mountains to the Atlantic, from the Gulf of Mexico to the Canadian border. In front of the cyclone, pushed up by the warm southerly winds, the temperatures were all above freezing and, in its southeastern quadrant, reached summer temperatures of 70°. Several hundred miles through its center, in the rear, the temperatures were below freezing in its northwestern quadrant and 30° cooler in its southwestern quadrant than in its southeastern quadrant. Compared with this tremendous storm disturbance, the tornadic outbursts it caused in Kentucky were insignificant local eddies which, on this map, can only be indicated by crosses, though their violence caused a loss of 113 lives and property losses of over $3,000,000, 76 being killed, 200 injured, and property damaged to the extent of $2,500,000 in Louisville alone.

The only difference between the conditions that caused the Louisville and near-by tornadoes and those that superinduced the St. Louis tornado and near-by outbreaks, on May 27, 1896, was in degree, not in kind. The March cyclone of 1890 was extensive in area and of great intensity; the parent cyclone of May 27, 1896, was a vague low area of the mild summer type, with a pressure at the center of only 29.70 inches, covering several States, St. Louis being in its southeast quadrant in the afternoon. The tornadoes this vague, weak cyclone set up in numerous localities were very destructive, the losses of life in and about St. Louis reaching to over 300 killed, with property losses of $12,000,000. The parent cyclone moved northeast and was central over the Lakes between Lake Huron and Lake Ontario on the afternoon of the 28th, with an increase in intensity, its center having a pressure of 29.40 inches, and, as local conditions allowed, it

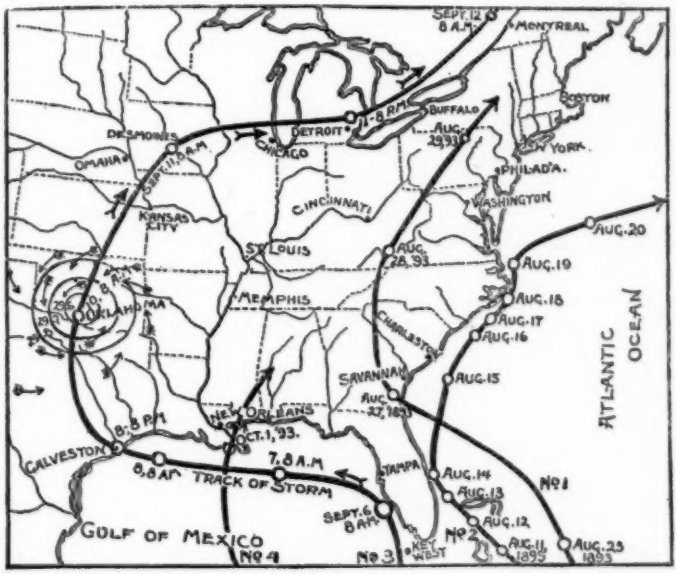

FIG. 4.

caused a handful of small tornadoes in Maryland, Pennsylvania and New Jersey, as well as a large number of thunderstorms.

CHART NO. 4.—This chart gives the track of four destructive tropical cyclones, known colloquially as 'hurricanes.' The hurricane differs from the continental cyclones of the North Temperate Zone in its surface effects in nothing but its intensity. The wind circulation is true to the cyclonic type (the term 'cyclone' was invented to describe the movement of the winds in the tropical tempest), but reaches great velocities, and, whereas the barometer in an intense continental cyclone may only fall to 29 inches in the tropical cyclone, its vortex may record 28 inches, and, in certain cases, the barometer has fallen to 27. In consequence of this, the vortical velocity of the wind is very great, reaching in gusts a rate of 80, 90, 100 and 125 miles an hour. As one of these tropical eddies advances from the West Indies and moves up the Atlantic Coast, it gives all localities north of its center, successively, gales from the northeast. These August-September, northeast gales, erroneously called 'equinoctials,' are but a part of the hurricane's

whirl, but with the heavy rain and high tides are its most familiar attribute to the Gulf Coast and Atlantic Seaboard peoples.

The violence of these northeast gales and of all the hurricane winds that blow about the vortex has nothing to do with the storm's progressive motion, which is often less than 10 miles an hour, since this is controlled by the general circulation; the westward drift of the tropics, until it gets north of the parallel of 30°, and later by the eastward-moving currents of the North Temperate Zone. When the tropical cyclone gets into this more northerly system it behaves exactly as a regular continental cyclone, and has to take its chances in the action and interaction of the polar cyclones and anti-cyclones that cover the continent. Hence the variations in its path, a few of which are given here.

Track No. 1 is that of the cyclone that caused the disaster on the Sea Islands near Savannah and Charleston, in September, 1893, causing a loss of over 400 lives (some claim 1,000 in all), leaving 30,000 homeless and destitute. It also proved destructive as far north as Long Island. Track No. 2 is that of the Porto Rican cyclone of August 8, 1899, that caused a loss of 2,900 lives with 500,000 people more or less affected by its devastating effects. Track No. 4 is that of the storm that caused a loss of nearly 2,000 lives along the coast and in the bayou district of Louisiana, in October, 1893.

In the case of the great Galveston cyclone (track No. 3), an anti-cyclone lying over the Middle States held it up as it was moving in toward Florida, and its path was deflected westward. It moved about 10 miles an hour along its track from September 6 to September 9, while the vortical winds were blowing toward and about the center at a rate of from 50 to 100 miles an hour, as Galveston learned on the 8th, the severest blow coming from the southeast after the center had passed Galveston. From the 9th to the 11th it decreased in intensity, and, when central over Oklahoma, on the 10th, had all the appearance of an ordinary rainy 'low area.' In jumping from Des Moines on the 11th to near Montreal on the 12th, it increased in energy; the rate of progression was about 50 miles an hour, at the same time its vortical winds over the Lakes reached a velocity of 72 miles. On the 13th it was over Newfoundland, and caused great damage to shipping on the 'Banks,' and reached Iceland on the 20th, traveling from September 1, when it originated south of Porto Rico, to September 20, over 7,000 miles, and at times covering, in diameter, regions 1,000 miles across.

THE PHILIPPINES TWO HUNDRED YEARS AGO.

By Professor E. E. SLOSSON,
UNIVERSITY OF WYOMING.

"I NOW and then, as occasion offers, undertake to plead the cause of the *Indians* in the *Philippine* Islands, as many more have for those of *America:* This is tolerable because grounded on compassion, mercy and the inclination of our kings and their supreme council of the *Indies,* who love them as their children, and give repeated orders every day for their good, advantage, quiet, satisfaction and ease. There is no other fault to be found with those poor creatures but that which *S. Peter Chrisologus* found in the holy innocents, *whose only crime was that they were born.* There is no reason for all their sufferings but their being in the world; and it is worth observing that tho' so many pious, gracious, and merciful orders have passed in favor of them, yet they have taken so little effect. . . . So that these Wretches have been several times redeemed, yet they remain in perpetual servitude. *Salvianus, lib. 6, de Provid.* says thus, *All captives when once redeemed enjoy their liberty, we are always redeemed and never free.* This sutes well with what we speak of. To which we may add that of *St. Paul, 2 Cor. 8. 13.* It is a subject deserves to be considered, and much authority and a high hand must make the remedy work a due effect."

These words, written by R. F. F. Dominick Fernandez Navarette, Divinity Professor in the College and University of St. Thomas, at Manila, are as applicable to-day as in 1656. The natives have been delivered several times since then, but are still in bondage, and much authority and a high hand are still needed to carry into effect the good intentions of their distant rulers. The good father does not let his piety blind him to the sins of his own brethren, but declares plainly that the 'Christians of *Manila* are worse than the infidels of *Japan.*' On the other hand, he never omits an opportunity to praise the docility and innocence of the Filipinos. "All those *Indians* are like our plain countrymen, sincere and void of malice. They come to church very devoutly; not a word was spoke to them but produced fruit; would to God the seed were sown among them every day; but they have mass there but once in two or three years. When they die, there's an end of them; but great care is taken to make them pay their taxes, and the curate's dues." "It were endless to descend to particulars. I know that in my time a governor of *Ilocos* in two years made fourteen thousand pieces of eight of his government; what a condition did he leave the *Indians* and their country in? It were well that those who write from thence would speak plain, and point at persons and things, and not do in general terms, leaving room to blame those that

are innocent, and clear the guilty. This must be either a design or malice." Our newspaper correspondents at the present time would do well to follow this advice.

The Filipinos at that time were not only oppressed by taxation and corvées, but they were transported as slaves in such numbers as to threaten to depopulate the islands. "There is not a ship sails from Manila, whether it belong to *Siam, Camboxa,* or the *Portugueses,* &c., but carries away *Indians* out of the islands."

A missionary who was in earnest had no easy time of it in those days in the Philippines. Perils from wild beasts, earthquakes, storms, disease and shipwrecks were frequent enough to abash the stoutest heart, and, according to Navarette's naive account, it appears that his fortitude was due more to the presence of courage than to the absence of fear. He was badly frightened by thunder and the upsetting of his canoe, but he managed to absolve his companions who were floating in the water, although he was in great distress that there was no one to absolve himself. Although all his personal possessions were lost in this accident, he rejoices that the bottle of mass wine, being nearly empty, floated and was washed ashore. His first experience with an important earthquake is quaintly told. "Upon St. *Philip* and *Jacob's* day I was in great trouble; I was hearing confessions in the chapel, and observed that the cane chair on which I sat moved. I imagined a dog got under it, and bid the *Indian* to turn him out. He answered, Father, it is no dog, but an earthquake. It increased to such a degree, that leaving the penitent, I kneeled down, to beg mercy of GOD. I thought that the end of the world had been at hand."

One of his fellow priests was devoured by an alligator, a fate that distressed Father Navarette exceedingly, since such a burial-place could hardly be consecrated, but he consoled himself with the saying of St. Augustine that "a good death is that which follows a good life, be it of what sort it will. . . . The good *F. Lewis Gutierrez* having lived so virtuously, said two masses that day, and being about to say the third, who is there that can doubt of his good disposition?"

As if the natural dangers of the Philippines were not enough, he was molested by enemies from the lower world. At Batam (Batan?) he was much disturbed by witches or fairies, who made a great noise, threw stones and hurled about chairs in a terrible manner. Evidently the predilection of spirits for furniture moving is not purely American, as has been supposed.

The reception given by the people of Manila to the Japanese Christians, who were driven out of their native land by the great 'cross-trampling' persecutions, elicits the highest praise from one author; "Many were sick and with the leprosy, yet charity was such, that they carried them home to their houses to be cured; and they that had one of

them fall to his share, thought themselves happy, they looked upon them as saints, and valued them as relics of inestimable value. The governor, counsellors, townsmen, religious persons and soldiers, went, as it were to snatch a *Japanese*, either sound or sick. I don't question but it much edified the *Chinese* infidels that looked on; for tho' they observe and take notice of our faults, yet at that time they were sensible of the wonderful efficacy of our holy law. The presence of so many witnesses, and such as they are, ought to make our carriage and deportment such, as may make them by it know and glorify our GOD; a point *S. Thomas* proposes and treats of in his *opusc.* to the churches of *Brabant.* I heard afterwards some *Europeans* behaved themselves not so well towards the banished people of *Ireland.*"

The date line gave trouble in those days, as it has since. On reaching the Portuguese possessions in Macasar, he found that his Thursday was their Friday, a circumstance that caused some affliction to his conscience, for he had eaten flesh that day for dinner. With true professional ingenuity he overcame the difficulty by eating fish for supper and 'as to the divine office, tho' I was not obliged to all that of Friday, yet having time to spare, perform'd for both days.'

Volume IV. of this same collection of 'Voyages and Travels', which generally goes by the name of its publisher, Churchill, contains the 'Voyage Around the World' by Dr. John Francis Gemilli Careri. This author gives a longer and more detailed account of the Philippine Islands, and it is especially valuable for its description of all the various islands, their natural resources and the customs of the natives. He mentions seven localities where gold is found, and states on the authority of the governor of Manila that the annual production of gold gathered without the help of fire or quicksilver amounted to 200,000 pieces of eight. "As for Manila, the author of nature placed it so equally between the wealthy kingdoms of the east and west, that it may be accounted one of the greatest places of trade in the world. I am of the opinion that there are no such plentiful islands in the world." The author fully justifies his opinion by the statistics he gives of the cotton, tobacco, hemp, amber, civet, wax, pearls, quicksilver, sulphur and rare woods and medicinal herbs too numerous to mention here. The whole book is worth publishing, as there are nearly one hundred pages of the productions, history, geography, ethnology and natural history of our new possessions as they were in 1697. Most of it appears reliable, for Gemilli is careful to distinguish what he sees from what he hears, and, although he includes many incredible stories, it is not uncritically. For example, he has an account of a leaf which when it ripens becomes an insect and flies off. A diagram is given of this, showing how the stem becomes the head, the mid-vein the body and the side fibers the legs of the insect, and the statement is sworn to by the provincial of St. Gregory's, an eye-witness of the metamorphosis, and attested by a bishop. Still the

author ventures a rationalistic interpretation, that the leaf conceals a worm which hatches into a butterfly. A more probable explanation, judging from the cut, is that it is a case of leaf mimicry by a moth.

On the Island of Panay, the Spaniards told him that when it thunders there fall crosses of a greenish-black stone which have great virtue. Here, too, the author is skeptical and suggests that 'it is possible they might make 'em of the stones that fell.' It is, however, not uncommon for fulgurites, formed by the fusion of the sand by lightning, to have a branching form like a rude cross.

It appears that a great many of those curious creatures of the class described by Herodotus, Ptolemy, Pliny and Mandeville have taken refuge from advancing civilization in the Philippines. Here were to be found mermaids, not only of the common species, but its converse form. Besides were-wolves, there were even 'were-crocodiles,' if such a word can be used. The missing link was also a native of the Island of Mindoro, with tails half a span long. The account of the same tribe of Negrillos, four pages beyond, seems to have been written later, for the tails had grown. "Some fathers of the society of great credit told me, that these *Mangihani* have a tail a span long. In other respects they are brave, and pay tribute, but have not as yet embraced the Christian faith." The clause connecting the two sentences is more logical than it sounds. Mention should also be made of the Amazons which inhabited islands near the coast of Palapa; of the serpents which magnetized their victims, and of the monkeys which caught oysters weighing several pounds by fishing with their tails.

From a political point of view, it is important to note that not a tenth of the inhabitants of the Philippines owned allegiance to the King of Spain, and also that the Moluccas were formerly included as a part of the Philippines.

From Manila Dr. Gemilli set sail for California, which he gives evidence to prove *was* not an island, as had been commonly supposed, but *was* a part of New Spain. The paragraph in which he gives his opinion of the ocean, misnamed Pacific, is as stately and antiquated in its architecture as a seventeenth century galleon and forms a suitable close to these extracts from the ancient history we have annexed:

"The voyage from the *Philippine* islands to *America* may be call'd the longest, and most dreadful of any in the world; as well because of the vast ocean to be cross'd, being almost the one-half of the terraquous globe, with the wind always a-head; as for the terrible tempests that happen there, one upon the back of the other, and for the desperate diseases that seize people, in seven or eight months living at sea, sometimes near the line, sometimes cold, sometimes temperate, sometimes hot, which is enough to destroy a man of steel, much more flesh and blood, which at sea had but indifferent food."

PREHISTORIC TOMBS OF EASTERN ALGERIA.

By Professor ALPHEUS S. PACKARD,
BROWN UNIVERSITY.

FROM the wonderful hot baths at Hamman-Meskoutine, which are situated near the Tunisian border of Algeria, on the railroad leading from Constantine to Tunis, one can visit the little-known necropolis of Roknia.

On a delightful morning near the last of January, with a Moorish guide, we set out for this locality. We had arrived at the baths only the evening previous, having left Constantine a couple of days before. In passing along the 'Tell,' or Algerian highland, the nights had been cool and we saw the hoar frost along the railroad at Setif; the pools of standing water were frozen over and the distant low mountains were capped with snow. But at this early hour flocks of thick-wooled sheep, and long-haired goats and herds of undersized whitish-gray cattle, with long, downy, thick hair, such as one sees on the highlands and elevated plains of Asia Minor, were grazing in the fields, while among them were scattered a few camels bending their tortuous necks over the herbage. Although in some winters an inch of snow may fall in the streets of Constantine, yet the winter climate of Algeria is most delightful. On sunny days the morning soon grows warmer, and by noon the heat is almost summer-like.

We had not heard of Roknia and its dolmens until the evening we arrived at Hamman-Meskoutine, when we at once made arrangements for a horse and guide to the tombs, and for an early start the next morning.

Meanwhile, we found the springs wonderfully interesting. They lie about half a mile from the railroad station, on the edge of a plateau. The water carries lime in solution, is of a temperature of about 220° Fahr., and has deposited on the hillside an elevated platform of calcareous sinter and travertine, with several imposing crater or tower-like cones, six and ten feet high, from which formerly poured streams of hot water and steam. The water of the stream overflows the tanks and natural basins, and passes in cataracts down the declivity to enter the little river, the Oued Chedakra, draining the valley, while clouds of steam hover over the scene. These baths were used by the Romans, and the grounds of the hotel are adorned with the remains of bathtubs, statues and broken columns of marble.

Our way to Roknia lay for six miles through a hilly country, with

Kabyle farms and houses near the point of departure; but beyond it stretched along narrow paths, winding around the brow of hills, up towards the mountains, which form an extended amphitheater. The horse furnished me by the proprietor of the hotel was a phenomenally wretched steed, by no means boasting of Arab blood.

After a couple of hours' march, we passed a 'douar' or Berber village on our left, a little off the path, partially hidden among the scrubby mastic trees. The little houses were built of stone and mud, with thatched roofs. Three villagers came out to meet us, one of them armed with a gun, and the question arose in my mind whether these good people were honest or had no reputation to lose; but soon the gunner left us, perhaps on the quest for partridges, while our beturbaned Moors in their ragged burnooses spent the rest of the day with us and seemed mild and inoffensive, receiving our parting salutations and backsheesh with kindly glances.

In another half-hour we reached the site of the necropolis. The vast cemetery is finely situated on the brow of a hill, or range of hills, facing west and overlooking the village of Roknia at its foot. This hillside or plateau itself is a spur of the Diebel-Debar range, somewhat elevated, being about 2,000 feet above the Mediterranean, and surrounded to the west, northwest and north by an amphitheater of distant mountains. The tombs themselves mostly occur in openings among the low trees or shrubs, which are scattered over the plains, or form dense thickets concealing the ruins of the dolmens. Scattered about the vicinity of this once sacred ground are the farms of the little hill villages, or 'douars' of the natives.

The material for the rock structures crops out here and there, the soil being thin—a pale gray, moderately hard limestone of cretaceous age, not containing any fossils and evidently weathering somewhat rapidly, as it is naturally somewhat porous and cavernous. The rock was not jointed, and evidently was not easily quarried; hence the blocks are very irregular and were never hammered.

The guide led us to the best preserved and most typical dolmen, which was smaller than we expected, being much less than half as large as those we had some years previously visited in Brittany. It is built of three rude slabs of limestone, one on each side, and a shorter stone at the end, the opposite end of the enclosure being open and facing the east. The enclosure thus walled in was covered by a single large slab, about six feet long, irregularly triangular in shape, the ends of which projected beyond the enclosure. Another less perfect tomb was built of two side-stones and an oblong slab on top, about five feet long and two feet wide. The space thus enclosed averaged about four by two feet. A still larger dolmen consisted of two side-slabs and one at the end, covered by an irregular slab, about six feet long and four

feet wide. The largest dolmen observed was covered by a quite regularly oblong slab about nine and a half feet long and four or five feet wide. There were but two side stones, but several at the end. It was only about a foot above the level of the ground, and the interior was about four feet deep and three and a half feet wide. In another the lateral stones were nine feet long and over five feet high, with eight or nine stones at each end. Others had a slab at each end. These may have been modified at a later period, for the Romans had occupied this valley, this region being a portion of the Numidia of Latin authors.

The average measurements of the dolmens given by Bourguignat are from one meter to 1.25 in length, 0.50 to 0.75 in breadth, and 0.60 to 0.80 meter in height.

The dolmen-field, so far as time allowed us to observe it, was from about eight hundred to a thousand yards long, and in width about five hundred feet. The dolmens themselves were arranged irregularly in lines about fifty feet apart, and the lines extended in an easterly and westerly direction. Bourguignat states that the general orientation is southwest and northwest, the four angles of the dolmens corresponding to the four cardinal points.

The rows of dolmens extend down to near the bottom of the valley, to a point near the little hamlet of Roknia, which is built of stones, with the pitched roofs thatched, and the rough walls not whitewashed, though they often are in the well-to-do 'douars.'

The interior or floor of the dolmen consisted of a soft black loam, and I set one of the Moors, whom we will call Mahmoud, digging up the soil with his stick. He soon unearthed a human radius, some vertebræ and a portion of a human skull, besides several specimens of the common European snail (*Helix aspersa*), of which more anon.

It will be readily seen that the bodies of the dead in dolmens of the dimensions of those of Algeria must have been bent or doubled up in order to be buried. The dolmens of the land of Moab, east of the Dead Sea, are also said to be small. On the other hand, those of France and Holland are often twelve feet in length and in some of them a person could stand upright.

There were no traces of tunnels (*allées couvertes*) to be seen by us, nor any indications that earth had been heaped over the dolmens, as is frequently the case in Brittany. Bourguignat, however, states that the dolmenic chamber was covered with a tumulus. On the other hand, no tumuli are known to exist in Tunisia.

In the time at our command it was not possible to examine the whole cemetery, as the greater part of it was in ruins or overgrown with the mastic or lentisk shrubs (*Pistacia lentiscus*) which yield the gum-mastic.

Moreover, many of the dolmens had evidently been destroyed, as we

found but few perfect ones, and it is stated that some French officers had wantonly destroyed them.

In 1867 Dr. Bourguignat, the well-known conchologist and archeologist of Paris, visited this necropolis, camped on it, and his account is the only complete one. He put the number of dolmens remaining in his time at fifteen hundred, and estimated the total number formerly existing at several thousand. He regarded this vast assemblage of megalithic sepulchers as a colossal cemetery.

In the following year General Faidherbe, in a paper published in the 'Annales de l'Académie de Bone,' attributed these sepulchers to the troglodyte Libyans, whose actual descendants were, he states, the Kabyles and Berbers.

The people living in this vicinity, and, presumably, the builders of these sepulchers, were of a later date than the neolithic or later stone epoch, for the art-objects excavated by Bourguignat from the interior were bronze rings or bracelets, amulets and rings of silver gilded with gold; and earthern vases. According to the well-known anthropologist, Pruner-Bey, the human skeletons contained in the tombs were those of Aryans, of negroes, Egyptians and Kabyles, with hybrids between the negro and Kabyle women. The Aryans occupied the large sepulchers; their cranial type resembled that of ancient Italy.

The dominant race, according to French statements, had imposed on the other peoples its mode of burial and its religious beliefs, since the eastward orientation of the sepulchers of Roknia is identical with the traditional position made sacred by Aryan customs.

The remains of the men were distinguished by an earthen vase placed near the head, but the women were not considered worthy of the honor of a funeral vase.

The question arises as to the exact age of these dolmens and their builders. Were they contemporaneous with the early Egyptians, and was the bronze age of northern Africa of the same or of an earlier date than the bronze epoch in Egypt?

Dr. Collignon has, more recently, thrown much light on the affinities of the builders of these dolmens, who, he suggests, were Berbers, and perhaps of the same race as the dolmen-builders of France and the Cromagnon family whose remains were found at Les Eyzies, in Dordogne, France. Of the races of the sedentary population now living in Tunisia, where also occur numerous dolmens, especially at Ellez (which is situated about 100 miles east of Roknia), there are five types of Berbers. "One of these types reaches its greatest purity in the neighborhood of Ellez and its area of distribution almost exactly covers the area of distribution of dolmens. Moreover, this race presents plainly the special anatomical characters of the bones found in the dolmens of France, notably at Sordes and at Homme-Mort, *i. e.*, a feeble

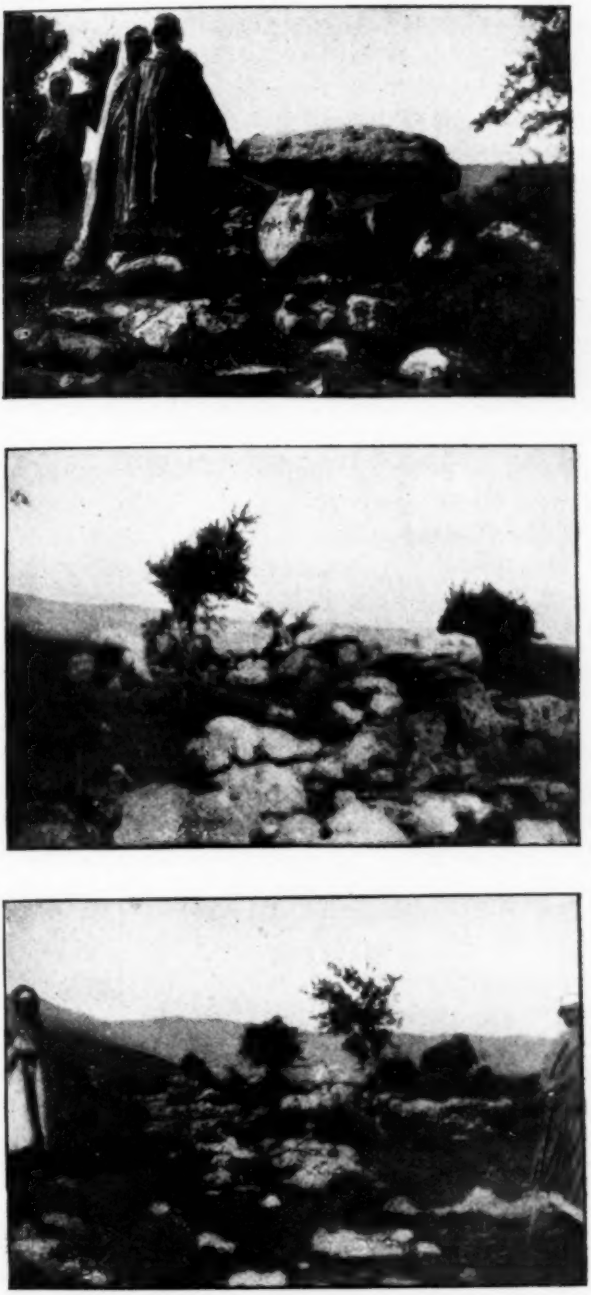

FIG. 1. THE DOLMENS AT ROCKNIA, ALGERIA.

size (1m, 63), dolichocephaly of 74 and especially a short face, broad and disharmonic, of a character absolutely analogous to the conformation of the crania of Cromagnon. They are not blonds.

"Another race of large size (1m, 69, about), very dolichocephalic, mesorhine to 75, etc., were probably the descendants of the men who worked the silver in this region, and they represent the most ancient ethnic layer existing in the country." He adds that in Tunisia, as in Europe, there was a gradual transition from the Chelléan to the Mousterian epoch, and also down through the Magdalenian epoch to the Neolithic. Flint implements were still used during the Roman occupation, though the nomadic Getulæ or Numidians used metal purchased of the Phœnicians and Romans.

It is now tolerably well settled that at the time of the paleolithic or old stone epoch in Egypt and Nubia, the Nile was much larger and wider than now, as the paleolithic axes and scrapers, precisely like those of France, have been found on the river gravels out on the desert as high as 400 feet above the present level of the Nile. On the other hand, the polished axes or celts, the arrow-heads and flint knives and scrapers of the neolithic epoch found under the temples and in the sand about the towns built within historic times, though extending back 2,500 to 4,000 years, preceded the bronze period, which may have begun about 1,500 years B. C. Since the opening of the neolithic epoch in Egypt, the Nile has assumed its present size, the country having become dry and rainless. There are everywhere, as we ascend the Nile to the first cataract, evident traces in the eroded hills on either bank of the Nile of a rainy and cooler climate during paleolithic times.

And everywhere in Morocco, Algeria and Tunis, and on the edge of the Sahara Desert, we saw evidences of an originally moist, rainy, cooler climate. Old lake-bottoms, on the Tell, where the rivers, now dry, had widened into lakes; conical hills, outstanding pinnacles and ancient water-worn courses extending down the sides of the now dry and barren cliffs or slopes, told the story of a climate more favorable than now for the sustenance of a comparatively large population; one fond of uplands, forest clad, cool and shady in the summer, and whose farms suffered less from the parching heats of summer. During the tertiary period, at least until the pliocene, the Sahara was a Mediterranean sea; northern Africa belonged then more to Europe than to central and southern Africa.

Rabourdin asserts that the desert of the central Sahara was formerly a fertile and inhabited country, and afforded pasturage for cattle. Herodotus states that the cattle had larger and thicker hides. There are rock pictures representing cattle with large horns.

Weisgerber states that according to local traditions the Sahara was formerly not a desert; that there were springs, streams and a luxuriant

vegetation, and that it supported a race, not numerous, however, which cultivated the soil. (Monuments archéologiques du Sahara, 1881, Bull. Soc. d'Anthropologie, Paris.)

Strong confirmation of the view that decided climatic changes have taken place in eastern Algeria since the time when the Roknia necropolis was built, is afforded by the excavations of Dr. Borguignat in these dolmens. He found in the dolmens numerous shells of *Helix aspersa*, a large snail common in the gardens and fields of Europe. These shells were similar to those living in the damp and cool climate of Europe, while those actually living at Roknia offer features produced by the dry and hot climate of the present day. This sufficiently indicates a decided change of climate, which must have occurred certainly more than a thousand years before the time of Homer, or of the founding of Rome. We dug up some of these semi-fossil shells, and also found plenty of the recent ones on top of the soil within the dolmens.

Many authors attribute the dryness and sterile nature of the eastern lands to the removal of forests by man within historic periods, but this is a decided mistake. There has been a slow secular process of elevation, desiccation and consequent deforestation of the regions around the Mediterranean, which began to take place thousands of years before the founding of the ancient civilization of Egypt, Babylon and Assyria, at, if not before a time when neolithic culture gradually supplanted that of the race which used only rough, unpolished, unmounted flint implements, scrapers and spear-heads. But for several thousand years, at least from 5,000 to 10,000 years B. C., if not throughout the neolithic epoch, the scenic features and climate of Egypt, Libya and Algeria have remained unchanged.

Bourguignat claims that the climate indicated by the snails of the Roknia dolmens nearly corresponds to that of Paris, whose mean temperature at our time is 10°.1 C. (about 52° F.), while that of Roknia is 17°.5, being a difference of 7°.4.

Reasoning from these data and certain astronomical calculations, this author decides that the mean annual temperature of Roknia, at a period 2,200 years B. C., was 10°C. Moreover, as the snail shells showing the influence of this cool, rainy climate were found in the lower beds of the sepulchral chambers, in the strata in contact with the human bones, he concludes that the megalithic monuments of Roknia extend back to that date. They are thus not less than about 4,000 years old, and thus it would appear that the bronze age of ancient Libya goes back that length of time.

This once decided, Dr. Bourguignat explained the presence of ornaments of bronze and gilded silver, which he supposed the inhabitants were unable to make themselves, to commercial exchange with the Egyptians and what he calls the people of Nigritia. The Kabyle in-

dustry, he thought, was confined to the manufacture of large coarse pottery, evincing an incipient stage in the ceramic art, and indicating a pastoral people, with abundant flocks and herds, the hillsides and plains there being covered with magnificent forests and affording abundant pasturage, there being perhaps 150 rainy days instead of 50 in the year, as at present.

But the noonday hour had passed, and we ate our frugal lunch, provided by the landlady at the hotel, with a bottle of native Algerian wine. We were forced to eat it alone, for in vain did we press on our guide and the two Moors a bit of bread and butter and a drink of the mild beverage. They steadfastly refused, for it was the month of the Ramadan. They were strict, consistent Mohammedans, and could not be tempted.

On our return, not far from the necropolis we passed by Moorish farmers stirring the light soil with their primitive wooden ploughs, shares and all, the yoke being bound around the neck of a cow or steer by cords behind the horns. The cattle were all gray and dirty white, no red or parti-colored ones being observed. Half way back we paused to examine the Roman ruins, portions of basement stones strewn about the ground. The warmth of the afternoon sun was like that of a June day. We left the native 'douars' behind, and after two or three hours' descent from the hills behind us, forded the little river and entered the village of Hamman-Meskoutine.

THE NEW YORK AQUARIUM.

By Professor CHARLES L. BRISTOL,
NEW YORK UNIVERSITY.

WHEN the municipality of New York transformed Castle Garden from an immigrant station to a public Aquarium, its location alone solved two problems incident to the usefulness and maintenance of such an institution. Its position, at the end of the Island of Manhattan, at the confluence of two great rivers and the harbor, in close proximity to all the lines of communication with all the boroughs, makes it equally accessible to all portions of the population, and provides for an abundant supply of salt water.

The Aquarium has well repaid the labors of those who conceived and wrought out the idea, and has justified the care and personal interest bestowed upon it by President George C. Clausen, of the Park Commission, if one may judge by the delight expressed by the great number of people, young and old, rich and poor alike, who daily enjoy the marvelous exhibition of fishes and other aquatic animals there set before them. Col. James E. Jones—the director—takes great pride, and justly, too, in the unbroken record of an 'open house,' and the general well-being and contentment of his finny charges.

The doors of the Aquarium are open free to all comers every day between the hours of nine and four, and, at this writing, the average daily attendance is more than fifty-one hundred people, while on Sunday this number rises to eleven thousand.

A word about the building before we enter it. It was built just before the war of 1812, and named Castle Clinton. It was then two hundred feet away from the shore, and was connected with it by a bridge; later the shore line was extended to its present location so as to include the building within it. Never very useful, the Federal Government gave it to the city in 1822. As a public hall the city welcomed in it many prominent persons, among whom were La Fayette, whose landing was commemorated in the blue and white pottery of those days; Kossuth, the Hungarian patriot, and the present Prince of Wales. Jenny Lind made her début there under the management of Phineas T. Barnum, at that time a youth unknown to fame. Then its halcyon days passed, and it became the reception hall for the vast numbers of immigrants who yearly passed through it into the life of the republic. In 1896, it was restored to the people as a place of amusement, and entered upon its second and, let us hope, its permanent career as an

Aquarium. As we approach, before passing into the dim light of the Aquarium, it is well to linger for a moment in the park, and gaze upon the wonderful scene spread out before our eyes—the commodious harbor, alive with the craft of all nations, the hills of Staten Island and the Narrows beyond.

Its circular fort form is admirably adapted to its present use, as the plans and illustrations show, and but few changes were necessary to make it available. Upon entering, the visitor's attention is attracted to the seven great pools on the floor. A second glance reveals the wall tanks, arranged in two tiers. These have glass fronts, and, at a

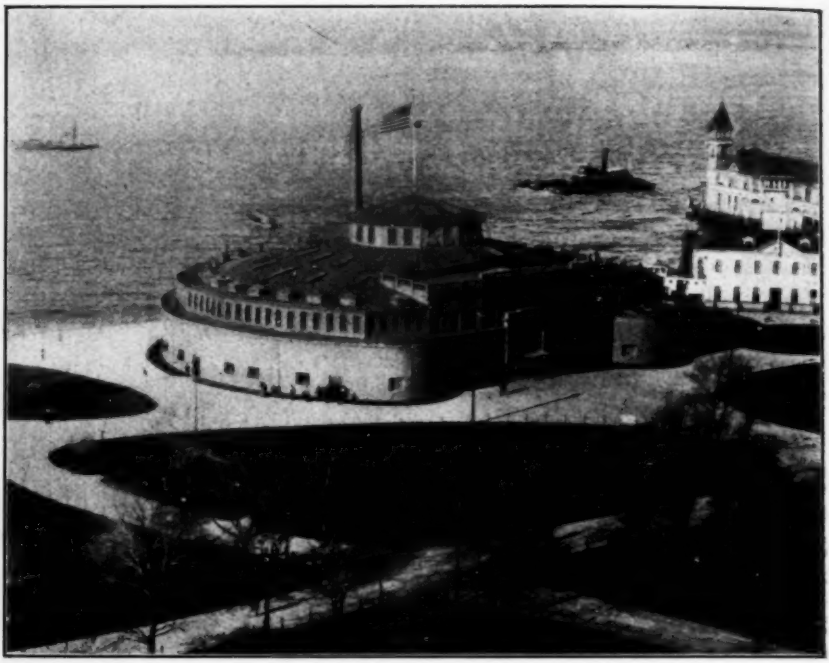

FIG. 1. THE NEW YORK AQUARIUM.

distance, look like beautiful pictures in great frames. They are lighted from behind and above, and the spaces immediately in front of the main and gallery tiers are thrown into deep shade by the gallery floor and the ceiling. The light coming through the tanks being the only source of illumination, the colors and markings of the fishes are brilliantly displayed to the spectator, who might easily imagine himself wandering in some submarine gallery.

In the great central pool there is, ordinarily, a collection of sharks and the common fishes of the coast, but when a whale or other large specimen is secured it occupies this place of honor. The three pools

on the north side of the floor contain, respectively, salmon raised from the fry, harbor seals and sturgeon. The harbor seals are always surrounded by an admiring throng, who watch the graceful manœuvres of 'Nelly' and her companion, the 'Babe.' 'Nelly' has occupied her quarters since the Aquarium was opened, and is a great pet with her keepers. The pools on the south side contain striped bass, the West Indian seal and sea turtles. The specimen of the West Indian seal—*Monachus tropicalis* (Gray)—is unique among zoological collections. It was captured at the Triangles, off the coast of Yucatan, in 1897, and has thriven in captivity at the Aquarium. It has developed into a humorist, and a favorite trick is to sit upright in the pool and look innocently

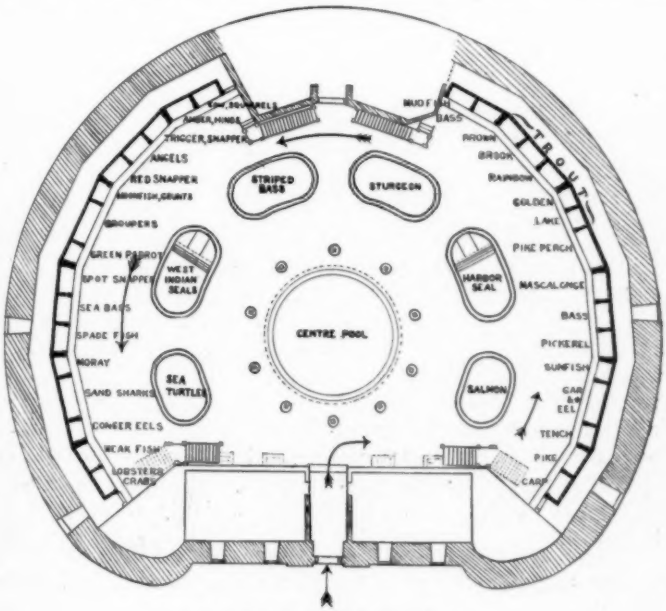

FIG. 2. PLAN OF THE MAIN FLOOR.

around until someone attracts its attention. Then, without a gesture of warning, it spurts a mouthful of water at him and dives away to swim for some time as fast as it can about the pool.

These pools, and the wall tanks to the left of the entrance, are devoted to salt-water animals, while the wall tanks on the other side are stocked with fresh water animals, as shown in the plan of the floor (Fig. 2).

In the display of fresh-water fishes, the trout family holds first place, occupying more tank room than any other family, and comprising eleven species. This is largely due to the interest taken by the fishing fraternity in this family and to the generous contributions of the Fish Commissioners of several States.

The sunfishes make a brilliant display, as do the pearl roaches caught in Harlem Mere at Central Park. For downright homeliness the great eighty-pound channel catfish from the Mississippi takes the first place. The bow fin (*Amia*) and the gar (*Lepidosteus*) always attract attention, together with the carp and the whitefish that come from the Great Lakes.

Along with the fresh-water fishes are three groups of amphibians: great bullfrogs from New York State, the mud puppy (*Necturus*) from the great lakes, and the hellbender *(Cryptobranchus)* from the Ohio River. There is always a group of visitors in front of the tanks of the two latter animals, watching the beautiful gills of the mud puppy and commenting on the loose suit of clothes worn by the hellbender.

On the salt-water side, the tropical fishes furnish by far the greatest beauty and attraction. Their gaudy colors and strange forms are in strong contrast to the somewhat monotonous hues of most of our coast-wise fishes, but both are harmonious with their surroundings. In the clear, limpid waters of Bermuda and the West Indies, under a tropic sun, the 'sea gardens' flourish, and great purple sea-fans, bright saffron sea-rods, large clumps of bright red and vivid green sea-weeds make a brilliant setting for the higher forms of life.

The world below the brine.
Forests at the bottom of the sea—the branches and leaves,
Sea-lettuce, vast lichens, strange flowers and seeds—the thick tangle, the openings and the pink turf,
Different colors, pale gray and green, purple, white and gold—the play of light through the water,
Dumb swimmers there among the rocks—coral, gluten, grass, rushes—and the aliment of the swimmers,
Sluggish existence grazing there, suspended, or slowly crawling close to the bottom.

In such environment the beautiful Angel-fish, with its long, streaming, yellow fins and sky-blue body, is no longer conspicuous as in the tanks. The ruddy Hind conceals itself easily at the bottom, while the little Four-eyed-fish (so called), brilliant in golden livery with jet-black markings, vanishes from sight by merely shifting its position. On the other hand, the Parrot fishes—which range in color from bright grass green through blues and browns—are boldly conspicuous in their warning colors, for their flesh is poisonous to other animals, including man. The Squirrel-fish, in his brilliant scarlet coat, is equally conspicuous; for woe to the unwary captor that attempts to swallow him! His strong, sharp spine and rough scales would lacerate the maw of the hardiest carnivore, and he swims about among them free from any fear.

These tropical fishes exhibit the function of changing their color in a high degree. The great Groupers are worth watching as they move

about in the tanks. Now they are a dirty brown, now they change to alternating blotches of black and white, and *presto*, they are pure white. The Red-snappers and Yellow-tails change in the twinkling of an eye so as to be almost unrecognizable. Nearly all these fishes may emit flashes of light apparently at will.

The Cow-fish and its relative the Trunk-fish always excite the interest of the visitors, who are amused at their triangular, box-like bodies and odd manœuvres. Equally attractive are the Morays, of which two varieties are shown; the beautiful Speckled Moray and the great Green Moray. The specimens of the latter now in the Aquarium measure, respectively, seven and one-half feet and six feet long.

The collection of coastwise fishes is excellent, and it contains many rare and little-known varieties, such as the weird Moon-fish, the Spade-fish, the Crevallé, the Orange file-fish and the Barracuda, as well as the common food fishes of the markets.

The first requisite of an Aquarium is water, and, while very small aquaria may be, and are, successfully maintained without changing the water, by the use of plants to supply oxygen, this system would not answer at all for large tanks. In England and on the Continent many of the large aquaria store great quantities of water, both fresh and salt, in dark reservoirs, and use it over and over again, filtering and aerating it each time.

In the New York Aquarium this system is not used. Fresh and salt water are supplied to the tanks but once and carried away to the sewer. The fresh water is furnished from the city water mains. The salt-water supply was originally taken direct from the harbor, but, while digging in the cellar to lay a foundation, the workmen pierced a layer of hardpan clay, and water rushed into the excavation. Pumping did not lower it, and tasting proved it to be salt. It was at once utilized as a source of supply and proves to be excellent. The layer of sand underneath the clay is an immense filter bed that removes all suspended matter and furnishes clear, limpid water in unlimited quantity.

Both kinds of water are pumped into large reservoirs and flow thence by gravity to the tanks. Some of the piping is gutta-percha, but practice has demonstrated that first-quality galvanized iron pipe is entirely satisfactory, and it is largely used. Between the reservoirs and the tanks are devices for regulating the temperature, and these are necessitated by the extreme diversity of the collection.

In the summer, the fresh water supplied to the salmon family must be kept down to 55° F., while in winter the tropical salt-water fishes demand 70° F. The former is maintained by an ordinary refrigerating machine, the latter by utilizing the waste steam from the radiators and the pumps.

The exhibition tank, like much of the plant, is the outgrowth of

experience and failure. The front is made of plate glass nearly an inch thick, and this is fastened into a strong frame of iron, which, in turn, is firmly secured to the building. The joint between the glass and the iron must be water-tight, of course, but it must also be somewhat flexible, to accommodate the changes due to temperature and the bulging due to pressure. It is made by wedging the glass into a rebate with strips of dry basswood as firmly as possible; when these become water-soaked they swell, so as to make the joint perfect, and yet to allow the necessary play. To the rear side of the iron frame is bolted a wooden tank, narrower at the bottom than the top, and when this is in place it is given a coat of Portland cement for a lining. This lining gives a pleasing neutral tint for a background, is very clean, and,

FIG. 3. POOLS AND WALL TANKS.

should occasion demand, it may be readily replaced. The largest glass used is ninety by forty-eight inches for a single tank, but in some cases two tanks are thrown into one by cutting the partition walls, as shown in the shark tank (Fig. 3).

Between the exhibition tanks and the outer wall of the building is an annular corridor devoted to the purposes of administration, and to this the public is not admitted. Here the keepers and their helpers are occupied almost constantly in the multifarious duties that the conditions of maintenance impose; here the pumping machinery and the temperature-regulating apparatus are located, and here are the tanks that hold the reserve stock and those used for hospital purposes.

Cleanliness equal to that found on a private yacht is maintained, as a matter of course, and lies at the foundation of the uninterrupted

success of the institution. Subdivision of the work makes possible a routine of duties that proceeds as regularly and orderly as on board a man-of-war, and this is necessary, for now and then the sinuous eel plays his pranks and stops some outlet, threatening the institution with flooding.

No less important is an intimate knowledge of the fishes themselves. When fishes of different kinds are put together in a tank, they often war with each other until one kind is exterminated, and sometimes fishes of the same kind will not tolerate certain individuals. In one of the gallery tanks may be seen a single angel-fish brought from Bermuda four years ago. It is of surpassing beauty, but it kills every other angel that is put in the tank with it. No matter how

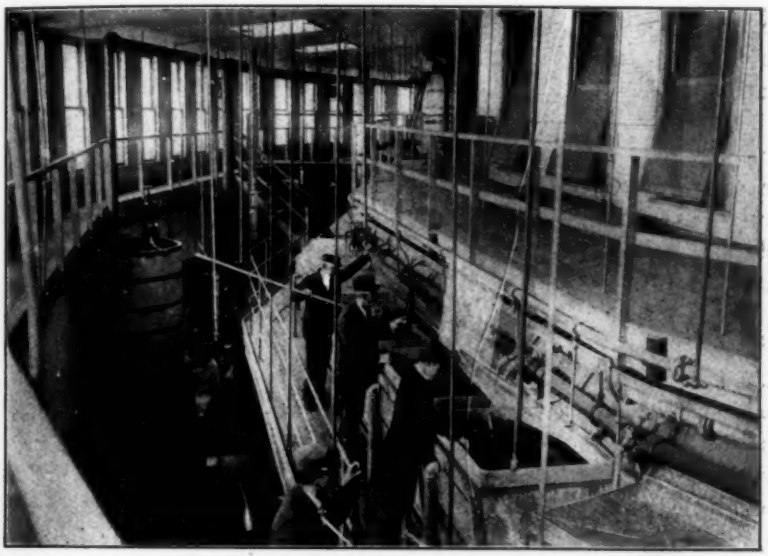

FIG. 4. THE CORRIDOR BEHIND THE TANKS.

many of the curious, triangular, hard-bodied trunk-fishes are put together, one is always made the butt of the rest, and worried by them until it dies, and then another is pestered, until but one is left. In many of the tanks where the fishes dwell in harmony together, there will be one that dominates all the others. It seems to demand a certain deportment and procedure from the others, and is always on the alert to exact compliance. The familiar story of the Mexican shepherds who know each individual in their vast flocks finds its parallel in the intimate knowledge of their charges possessed by the men who care for the tanks at the Aquarium, and this enables them to keep a delicate touch on the daily life in the tanks that contributes largely to the success recognized by the public.

For instance, a slight uneasiness in one of the fishes in a certain

tank was noticed one day; it continued, and the next day the fish was removed and carefully examined. It was found to have a few parasites upon it, and these were killed. Every fish in that tank was then examined and cleaned, the tank was thoroughly cleansed, and finally the reserve tank from which it came was similarly treated, with the result that no deaths resulted from that cause.

Besides animal parasites, they are always on the lookout for fungus growths, for some of these would decimate the tanks in short order if they were not destroyed. Fortunately, most of these yield readily to the treatment of a change of water. The salt-water fish is put for a short time in brackish or fresh water, or *vice versa*, and the plant is killed before the fish is injured. Sometimes one eye or both will bulge out of its socket, giving rise to what the Aquarium people graphically call 'bung-eye.' This is regularly treated in the hospital tanks and usually with success. Wounds and abrasions, mopishness and other troubles are recognized and treated in aquatic animals quite successfully.

Fully as exacting as questions of disease are the conditions surrounding the matter of feeding. The food must be fresh, much of it needs preparation, and it must be fed at proper intervals. Some fishes require feeding every day, others take it at intervals of three or four days or a week. The small fishes take their tiny meals of chopped clam every day, the larger fishes at varying intervals.

The dietary is varied, as the following list of some of the foods will show: Quahaugs or hard clams, soft clams, live shrimps, sand fleas, killifish (salt-water minnows), minnows, earthworms, sandworms (both white and red), fresh dead fish from which the bones are removed, salted codfish and beef's liver. Some of these are staples, some are tid-bits to tempt the appetite of moping or sick fishes, and of this latter sort salted codfish is far and away the most tempting.

The death rate among the inhabitants is surprisingly low; some forms will not endure captivity for any considerable time, as might be expected, but among those kinds that will live and thrive in confinement, there are many individuals that were put into the tanks when the Aquarium was opened in 1896.

The area from which the supply for exhibition is drawn is very large, exceeding, probably, that of any other aquarium in the world, and in this respect the collection in the New York Aquarium differs widely from those of the great aquariums of Europe, which rely upon the fauna of the immediately adjacent waters. The Gulf of St. Lawrence furnishes white whale; the Gulf of Mexico the West Indian seal. The cold streams of Maine supply the salmon, while from Bermuda come the tropical fishes of the West Indies. The great lakes contribute the whitefish and others, while the Mississippi Valley sends the catfish. Besides these, the fishes of the neighboring waters are well represented.

CHAPTERS ON THE STARS.

By Professor SIMON NEWCOMB, U. S. N.

THE CLUSTERING OF THE STARS.

A STUDY of Schiaparelli's planispheres, which we gave in the last chapter, shows that some regions of the heavens are especially rich in lucid stars and others especially poor.

Neither telescope nor planisphere is necessary to show that many of those stars are collected in clusters. That the Pleiades form a group of stars by itself is clear from the consideration that six stars so bright would not fall so close together by accident. This conclusion is confirmed by their common proper motion, different from that of the stars around them. The singular collection of bright stars which form Orion, the most brilliant constellation in the heavens, and the little group called Coma Berer ices—the Hair of Berenice—also suggest the problem of the possible connection of the stars which form them.

The question we now propose to consider is whether these clusters include within their limits an important number of the small stars seen in the same direction. If they and all the small stars which they contain were within their actual limits removed from the sky, would important gaps be left? The significance of this question will be readily seen. If important gaps would be left, it would follow that a large proportion of the stars which we see in the direction of the clusters really belong to the latter, and that, therefore, most of the stars would be contained within a limited region. The clusters which we shall especially study from this point of view are the Pleiades, Coma Berenices, Præsepe and Orion.

The Pleiades.—In the case of this cluster the question was investigated by Professor Bailey, by means of a Harvard photograph 2° square, having Alcyone near its center. It was divided into 144 squares, each 10′ on a side. The brighter stars of the cluster were included within 42 of these squares. The count of stars gave the results:

Within cluster: 1,012 stars, or 24 per square.
Without cluster: 2,960 stars, or 29 per square.

It, therefore, seems that the portion of the heavens covered by the cluster is actually poorer in stars than the region around it.

Two opposite conclusions might be drawn from this fact. Assuming that the difference is due to the presence of the cluster, we might suppose that the latter was formed of material that otherwise would have

gone into numerous smaller stars. Accepting this view, it would follow that the material in question was a sheet so thin that the thickness of the space filled by the cluster was an appreciable fraction of that oc-

FIG. 1. PHOTOGRAPH SHOWING STRUCTURE OF THE MILKY WAY, BY BARNARD.

cupied by the stars. In other words, one-fifth of the stars of the region would be contained in a thin sheet. This result seems too improbable to be accepted.

The other and more likely conclusion is that the number of very

minute stars included in the cluster is no greater than that in the surrounding regions, and that the lesser number in the region is to be regarded as accidental.

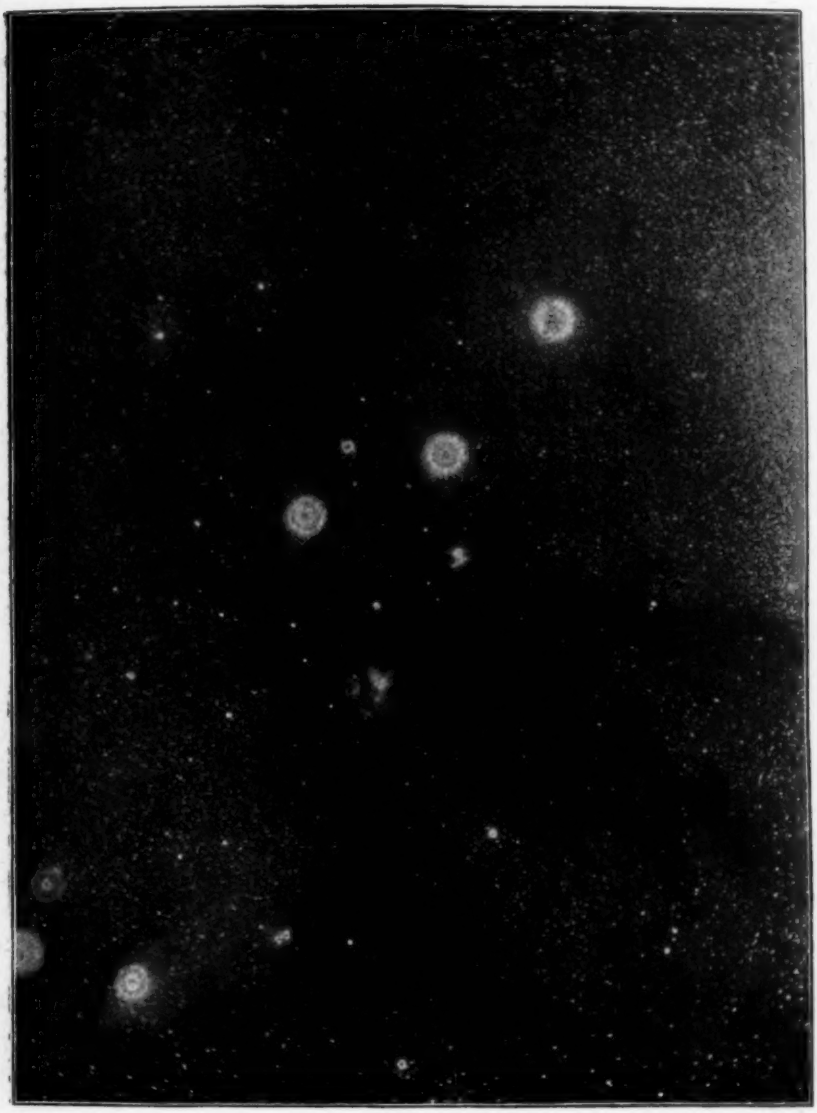

FIG. 2. RIFTS IN THE MILKY WAY, PHOTOGRAPHED BY BARNARD.

Coma Berenices.—This cluster, which may be seen east, south or west of the zenith on a spring or summer evening, contains seven stars visible to the naked eye, each of the fifth magnitude. It may be considered as comprised within the limits 12h. 13m. and 12h. 25m. of R. A.,

and 25° to 29° of declination, an area of 10°.5. This existence of seven lucid stars within so small an area suggests that they belong together, and may have smaller stars belonging to the group, and making the star-density of this area greater than that of the sky in general.

The question whether there is any corresponding excess of richness in the fainter stars will be decided by a count of those contained in Graham's section of the A. G. Catalogue, which extends to the ninth magnitude. With the area above defined this catalogue gives seventy-one stars. Subtracting the seven lucid stars, we have sixty-four small stars left within the area. To the same belt of declination 336 stars are listed in the twelfth hour of R. A., giving an average of sixty-seven stars to an area equal to that of the cluster. The small stars are, therefore, no thicker within the area of the cluster than around it. It may be added that the seven lucid stars do not seem to have any common proper motion, so that their proximity is probably an accident.

Præsepe.—This object, situate in the constellation Cancer, appears to the naked eye as a patch of nebulous light. It is actually a condensed group of stars, of which the brightest are of the seventh magnitude. The stars of the ninth magnitude included within the area of the group probably belong, for the most part, to it, but they are too few to serve as the base for any positive conclusion.

Orion.—I find by measurement and count that a circle 20° in diameter, comprising the brightest stars of this constellation, contains eighty stars to magnitude 6.3. Of these six are of the first or second, leaving seventy-four from the third to the sixth. The resulting richness is 24 to 100 square degrees, about the average richness along the borders of the galaxy. It follows that this remarkable collection of bright stars has no unusual collection of faint stars associated with it.

A very natural inquiry is whether the bright stars in Orion have any common proper motion, indicating that they form a system by themselves. The answer is shown in the following statement of the proper motions in a century:

Star.	Mag.	Proper Motions. R. A.	Dec.
		″	″
Rigel	1	+ 0.1	0.0
η Orionis	3	+ 0.1	— 0.3
γ Orionis	2	— 0.6	— 1.7
δ Orionis	2	0.0	— 0.2
ε Orionis	2	0.0	+ 0.1
ζ Orionis	2	0.0	— 1.4
κ Orionis	2	+ 0.1	— 0.3
α Orionis	1	+ 3 0	+ 0.9

For the most part these motions are too small to be placed beyond doubt, even by all the observations hitherto made. In the case of

α Orionis the motion is established; in those of γ and ζ it is more or less probable, but not at all certain; in all the other cases it is too small to be measured.

This minuteness of the motion makes it probable that these stars are very distant from us, an inference which is confirmed by the smallness of their parallaxes. The careful and long-continued measures of Gill show no parallax to Rigel, while Elkin finds one of only 0".02 to α Orionis.

The general conclusion from our examination is this: *The agglomeration of the lucid stars into clusters does not, in the cases where it is noticeable to the eye, extend to the fainter stars.*

Let us now study the question on the opposite side. The planispheres show regions of great paucity in lucid stars; is there here any paucity of telescopic stars?

The two regions of greatest paucity are near the equator; one extends through the hour of 0 of R. A.; the other from 12h. 20m. to 12h. 40m. The richness of these and of the adjoining regions may be inferred from Boss's zone of the A. G. Catalogue, including a belt from 1° to 5° of declination. The number of stars in each hour from 23h. to 3h. is as follows:

In 23h.: 271 stars.
In 0h.: 293 stars.
In 1h.: 299 stars.
In 2h.: 295 stars.

These numbers show no paucity in the hour 0, and no excess in the hour 2, which is much richer in lucid stars than the hour 0.

In the strip from 12h. 20m. to 12h. 40m. the catalogue contains seventy-eight stars, a richness of 234 to the hour. In the hour preceding there are 211 stars; in that following, 225. There is, therefore, no paucity in the strip in question.

THE STRUCTURE OF THE MILKY WAY.

The most salient problems suggested by the appearance of the Milky Way are to be approached on lines quite similar to those followed in the last chapter. We begin with a description of this wonderful object as it appears to the observer. We recall that it can be seen through some part of its course on any clear night of the year, and in the evening of any season except that of early summer. We begin with the portion which will be visible in the late summer or early autumn. We can then trace its course southward from Cassiopeia in the northwest. It passes a little east of the zenith down to Sagittarius, near the south horizon. This portion of the belt is remarkable for its diversity of structure and the intensity of the brighter regions.

In Cassiopeia it shows nothing remarkable, but above this constella-

tion, in Cepheus, we notice in the midst of the brighter region a nearly circular patch several degrees in diameter, in which little light is seen. A little farther along we notice a similar elongated patch in Cygnus lying across the course of the belt. In this region the brighter portions are of great breadth, more than 20°.

In Cygnus begins the most remarkable feature of the Milky Way, the great bifurcation. Faintly visible near the zenith, as we trace it towards the south, we see it grow more and more distinct, until we reach the constellation Aquila, near the equator. Between Cygnus and Aquila the western branch seems to be the brighter and better marked of the two, and might, therefore, be taken for the main branch. About Aquila the two appear equal, but south of this constellation we see the western branch diverge yet farther toward the west, leaving the gap between it and the eastern yet broader and more distinct than before. This branch finally terminates in the constellation Ophiuchus, while the eastern branch, growing narrower, can still be followed toward the south.

Between the equator and the southern horizon we have the brightest and most irregular regions of all. Several round, bright patches of greater or less intensity are projected on a background sometimes moderately bright and sometimes quite dark. If the night is quite clear and moonless we shall see that, after a vacant stretch, the western branch seems to recommence just about the constellation Scorpius. In this constellation we have again a bifurcation, a dark region between two bright ones.

This is about as far as the object can be well traced in our middle latitudes. From a point of view nearer to the equator it can be traced through its whole extent. South of Scorpius and Sagittarius it becomes broad, faint and diffused through the constellations of Norma and Circinus. It reaches its farthest southern limit in the Southern Cross, where it becomes narrower and better defined. The most remarkable feature here is the 'coal sack,' a dark opening of elliptical shape in the central line of the stream. West and north of this, in the constellation Argo, is the broadest and most diffused part of the whole stream, the breadth reaching fully 30°. Here we again reach the portion which rises above our horizon.

Returning now to our starting point, we shall notice that, as we make our observations later and later in the autumn, the southern part, which we have been mostly studying, is seen night by night lower down in the west, while new regions are coming into view in the northeast and east. These regions rise earlier every evening, and, if we continue our observations to a later hour, we shall see more and more of them above the eastern or southeastern horizon. By midwinter Cassiopeia will be seen in the northwest, and we can readily trace

the course of the galaxy from that constellation in the opposite direction from that which we have been following. South of Cassiopeia we see, near the central line, the well-known cluster forming the sword-handle of Perseus. Farther south the belt grows narrower and fainter; although the irregularities of structure continue, they are far less striking than on the other side. On a moonlight evening it will scarcely be visible at all. If the moon is absent and the air clear we shall see that it grows slightly brighter toward the southern horizon, near which will be the narrowest part of its entire course. Below is the broad and diffused region in Argo.

One conclusion from the inequalities of structure which we have described will be quite obvious. The Milky Way is something more than the result of the general tendency of the stars to increase in number as we approach its central line. There must be large local aggregations of stars, because, as we have already pointed out, there cannot be such diversity of structure shown in a view of a very widely stretched stratum of stars. When, instead of a naked eye view of the belt, we study the photographs of the Milky Way, we find this evidence of clustering to grow still stronger. It is shown very strikingly in the photograph by Barnard, showing the singular rifts in the Milky Way in the constellation Ophiuchus. Yet more singular are three-minute openings in the constellation Aquila, the positions of which are:

(1). R. A. = 19h. 35.0m.; Dec. = + 10° 17′
" = 19h. 36.5m.; " = + 10° 37′
" = 19h. 37.2m.; " = + 11° 2′

The fundamental question which we meet in our farther study of this subject is: At what magnitude do these agglomerations of stars begin? Admitting, as we must, that they are local, are they composed altogether of stars so distant as to be faint, or do they include stars of considerable brightness? We consider this question in a way quite similar to that in which we discussed the clustering of the stars in the last chapter. We mark out on a map of the Milky Way the brightest regions—that is, those which include the densest agglomeration of very faint stars. We also mark out the darkest regions, including the coal sack. For this purpose I have taken the maps found in Heis's *Atlas Cœlestis* for the northern portion of the Milky Way and the Atlas of Gould's *Uranometria Argentina* for the southern portion. In order to enable any one to repeat and verify the work I give the position of the central part of each patch or region studied. This serves simply for the purpose of identification. The outlines can be drawn by any one when the patch is identified. The third column of the table is given, approximately, the number of square degrees in the patch as outlined. Then follows the number of stars as found on the map. Here are included stars somewhat fainter than those regarded as lucid.

Heis maps all stars down to about magnitude 6.2 or 6.3. Gould gives the places of all stars to the seventh magnitude.

A.—*Number of lucid stars in certain bright regions or patches of the Milky Way.*

I.—Northern portion, from Heis.

Position of patch.		Square	Number
R. A.	Dec.	degrees.	of stars.
19h. 10m.	+35°	60	21
20h. 0m.	+37°	25	11
20h. 20m.	+47°	20	11
21h. 5m.	+45°	12	4
0h. 20m.	+60°	25	9
2h. 20m.	+55°	60	16
3h. 30m.	+36°	32	7
3h. 40m.	+44°	43	12
Sums.....		277	91

II.—Southern portion, from Gould:

Position.		Area.	Stars.
8h. 4m.	—47°	10	14
2h. 24m.	—44°	9	7
10h. 35m.	—58°	12	19
11h. 40m.	—62°	10	11
16h. 10m.	—53°	7	7
18h. 0m.	—28°	25	9
18h. 10m.	—18°	8	5
18h. 42m.	— 8°	16	5
Sums.....		97	77

B.—*Number of lucid stars in the darker regions or patches of the Milky Way.*

I.—Northern part, from Heis.

Position.		Area.	
R. A.	Dec.	Sq. Deg.	Stars.
21h. 0m.	+ 50	26	10
22h. 0m.	+ 67	33	7
22h. 25m.	+ 60	30	12
0h. 0m.	+ 69	56	10
4h. 0m.	+ 55	98	19
4h. 20m.	+ 35	98	13
6h. 15m.	+ 18	86	17
6h. 12m.	+ 4	48	9
Sums.		475	97

II.—Southern part, from Gould.

Position.			
7h. 22m.	— 38°	18	8
7h. 28m.	— 38°	12	5
8h. 0m.	— 22°	11	4
8h. 40m.	— 50°	30	16
9h. 0m.	— 45°	12	6
10h. 0m.	— 52°	11	5
12h. 40m.	— 63°	18	2
15h. 10m.	— 56°	31	3
17h. 30m.	— 27°	18	3
18h. 10m.	— 35°	18	7
18h. 0m. — 18h. 30m.	— 22° — 8°	24	10*
18h. 50m.	— 5°	16	5
Sums.		219	74

To derive the best conclusions from these numbers we must compare them with the mean star-density for the sky in general, and for the regions near the galactic plane. Heis has 3,903 stars north of the equator; Gould, 6,755 south of it. The area of each hemisphere is 20,626 square degrees. It will be convenient to express the various star-densities in terms of 100 square degrees as the unit of area. Thus we have the following star-densities according to the two authorities:

	Heis.	Gould.
Star-density of the entire hemisphere	19.0	32.7
Star-density of the darker galactic regions	20.4	33.8
Star-density of the bright-galactic regions	32.9	79.4

The first two pairs of numbers lead to the remarkable and unexpected conclusion that the darker regions of the Milky Way are but slightly richer in lucid stars than the average of the whole sky; certainly no richer than is due to the general tendency of all the stars to crowd toward the galactic plane. On the other hand, the bright areas are 60 per cent. richer according to Heis, and more than 100 per cent. richer according to Gould, than the darker areas seen among and around them. The conclusion is that an important fraction of the lucid stars which we see in the same areas with the agglomerations of the Milky Way is really in those agglomerations and form part of them.

A study quite similar to this has been made by Easton for the portions of the Milky Way between Cygnus and Aquila, where the diversities of brightness are greatest. His count of the stars in the bright and dark regions differs from that made above, principally by including all the stars of the Durchmusterung, which we may suppose to extend to about the ninth magnitude.†

* A long narrow region between these limits.

† Easton's work is given in detail in the 'Astronomische Nachrichten,' Vol. 127, and the 'Astrophysical Journal,' Vol. I, No. 3.

He divides the regions studied into six degrees of brightness. For our present purpose it is only necessary to consider three regions, the brightest, the faintest and those intermediate between the two. Besides the count from the Durchmusterung he made a count of the same sort from Dr. Wolf's photographs and from Herschel's gauges of the heavens. In the following table I have reduced all his results, so as to express the number of stars in a square degree in the three separate regions. At the top of each column is given the authority, whether Argelander, Wolf or Herschel. Wolf had two sets of photographs, one supposed to include all the stars to the eleventh, the other to the twelfth magnitude. The magnitudes included are given in the second line. That Herschel's count extends to the fifteenth magnitude is by no means certain; but we can judge from the great number of his stars that it goes considerably beyond Wolf's in the faintness of the stars included. Below this we give, in the regions A, B and C, which are, respectively, those of least, of medium and of greatest brightness, the number of stars per square degree according to each of the authorities:

Authority	Arg.	Wolf (A).	Wolf (B).	Hersch.
Magnitude	1—9	1—11	1—12	1—15 (?)
Region A	23	72	224	405
Region B	33	134	764	4114
Region C	48	217	1,266	6,920
C—A	25	145	1,042	6,425
Ratio C : A	2.1	3.0	5.7	14.0

The vastly greater number of individual stars per square degree in the brighter regions is what we should expect from the studies we have made of the lucid stars. But what is of most interest in the table is the continual increase in the proportion of faint stars in the separate regions. We notice that, when we consider only the stars of the ninth magnitude, there are twice as many in the brightest as in the darkest portions. When we go to the eleventh magnitude, as shown by Wolf's photograph A, we find the number of stars in the brighter regions to be threefold. When the twelfth magnitude is included we find that there are between five and six times as many stars in the bright regions as in the dark ones. Finally, when we come to stars from Herschel's gauges there are fourteen times as many stars per square degree in the brighter regions as in the dark.

At first sight this result seems to show a great difference between the clusters of stars described in the last chapter, and the collections of the Milky Way, in that the former include few or no faint stars, while the latter include a greater and greater number as we ascend in the scale of magnitude. This difference is important as showing a vastly greater range of actual brightness among the galactic stars than among those which form the scattered clusters. Allowing for this difference,

the results from the two classes of objects can be brought to converge harmoniously toward the same conclusion.

We have collected abundant evidence that, separate from the accumulations of stars in the Milky Way, perhaps extending beyond them, there is a vast collection of scattered stars, spread out in the direction of the galactic plane, as already described, which fill the celestial spaces in every direction. We have shown that when, from any one area of the sky, we abstract the stars contained in clusters, this great mass is not seriously diminished. We have also collected abundant evidence that the distances of this great mass are very unequal; in other words, there is no great accumulation, in a superficial layer, at some one distance. The question which now arises is whether the darker areas which we see in the Milky Way are vacancies in this mass. Although some of the counts seem to show that they are, yet a general comparison leads to the contrary conclusion. In the darkest areas of the Milky Way, when of great extent, the stars are as numerous as on each side of the galactic zone. Our general conclusion is this:

If we should remove from the sky all the local aggregations of stars, and also the entire collection which forms the Milky Way, we should have left a scattered collection, constantly increasing in density toward the galactic belt.

THE INCREASING NUMBER OF STARS WITH DIMINISHING BRIGHTNESS.

We mentioned in an earlier chapter that, when we compare the number of stars of each successive order of magnitude with the number of the order next lower, we find it to be, in a general way, between three and four times as great. The ratio in question is so important that a special name must be devised for it. For want of a better term, we shall call it the star ratio. It may easily be shown that there must be some limit of magnitude at which the ratio falls off. For, a remarkable conclusion from the observed ratio for the stars of the lower order of magnitude is, that the totality of light received from each successive order goes on increasing. Photometric measures show, as we have seen, that a star of magnitude m gives very nearly 2.5 times as much light as one of magnitude $m+1$. The number of stars of magnitude $m+1$ being, approximately, from 3 to 3.75 times as great as those of magnitude m, it follows that the total amount of light which they give us is some 40 or 50 per cent. greater than that received from magnitude m. Using only rough approximations, the amount of light will be about doubled by a change of two units of magnitude; thus the totality of stars of the sixth magnitude gives twice as much light as that of the fourth; that of the eighth twice as much light as that of the sixth; that of the tenth twice as much again as of the eighth, and so on as far as accurate observations and count have been made.

To give numerical precision to this result, let us take as unity the total amount of light received from the stars of the first magnitude. The sum total for this and the other magnitudes, up to the tenth, will then be:

Mag.	1	Light =	1.0
"	2	" =	1.4
"	3	" =	2.0
"	4	" =	2.8
"	5	" =	4.0
"	6	" =	5.7
"	7	" =	8.0
"	8	" =	11.3
"	9	" =	16.0
"	10	" =	22.6
Total			74.8

That is, from all the stars to the tenth magnitude combined, we have more than seventy times as much light as from those of the first magnitude.

There must, evidently, be an end to this series, for, were this not the case, the result would be that which we have shown to follow if the universe were infinite; the whole heavens would shine with a blaze of light like the sun. At what point does the rate of increase begin to fall off?

We are as yet unable to answer this question, because we have nothing like an accurate count of stars above the ninth, or at most, the tenth magnitude. All we can do is to examine the data which we have and see what evidence can be found from them of a diminution of the ratio.

It must be pointed out, at the outset, that the ratio must be greater in the galactic region than it is in other regions. This follows from the fact that the proportion of small stars increases at a more rapid rate in the galaxy than elsewhere. This is shown by the comparisons we have already made of the Herschelian gauges with the counts of the brighter stars. While the galactic region is less than twice as dense as the remaining regions for the brighter stars, it seems to be ten times as dense for the Herschelian stars. If we knew the limiting magnitude of the latter, we could at once draw some numerical conclusion. But unfortunately, this is quite unknown. All we know is that they were the smallest stars that Herschel could see with his telescope.

The ratio in various regions of the heavens has been very exhaustively investigated by Seeliger, in the work already quoted. The bases of his investigations are the counts of stars in the Durchmusterung. Instead of taking the ratio for stars differing by units of magnitude, as we have done, Seeliger divides them according to half magnitudes. The reproduction of his numbers in detail would take more space than we can here devote to the subject and would not be of special interest

to our readers. I have, therefore, derived their general mean results for different parts of the sky with reference to the Milky Way and for stars of the various orders of magnitude. The following table shows the conclusions:

Zone.	Ratio of increase.			Concluded result.
	D. M.	S. D.	Diff.	
I.	2.99	—	—	3.24
II.	3.00	3.49	0.49	3.25
III.	3.07	3.72	0.65	3.37
IV.	3.32	3.85	0.53	3.58
V.	3.55	4.15	0.60	3.85
VI.	3.28	3.68	0.40	3.48
VII.	3.23	3.55	0.32	3.37
VIII.	3.44	3.56	0.12	3.40
IX.	—	3.49	—	3.24

In the first column we have the designation of the zone or region of the sky, as already given.

In the second and third columns we have the mean ratio of increase for whole magnitudes as derived from the Durchmusterung and the southern Durchmusterung, respectively. It will be recalled that region I., around the north galactic pole, is entirely wanting in the S. D., while the adjoining regions, II. and III., are only partially found, and that, in like manner, the D. M. includes none of region IX. around the south galactic pole, and but little of the adjoining region.

It will be seen that there is a very remarkable systematic difference between the two lists, the ratio of the number of faint to that of bright stars being much greater in the S. D. This difference is shown in the fourth column. I have assumed that the two systems are equally good, and there diminished all the ratios of the S. D. by 0.25, and increased those of the D. M. by the same amount. The mean of the two corrected results was then taken, giving the principal weight to the one or the other, according to the number of stars on which they depend.

It will be seen that the increase of the ratio from either galactic pole to the Milky Way itself is as well marked as in the case of the richness of the respective regions in stars. We may condense the results in this way:

In the galactic zone, ratio = 3.85
In zones IV. and VI., " = 3.53
In polar zones I., II., VIII. and IX., " = 3.28

It will be recalled that zone V. is a central belt 20° broad, including the Milky Way in its limits. But the latter, as seen by the eye, especially its brightest portions, does not fill this zone. These portions, as we know, comprise the irregular collection of cloud-like masses described in the last chapter. Seeliger has investigated the ratio within

these masses, and compared it with the stellar density, or the number of stars per square degree. The mean results are:

In that portion of the galaxy extending from Cassiopeia to the equator near 6″ of R. A., ratio = 4.02.

In that portion from Cassiopeia in the opposite direction to near 19″ of R. A. in Aquila, ratio = 3.70.

These remarkable results are derived from the D. M., and will be yet more striking if corrected by half the difference between it and the S. D., as we have done for the sky generally. They will then be 4.27 and 3.95, respectively.

As might be expected, the regions of greater star density have generally, though not always, the higher ratio. The highest of all is in a patch south of Gemini, between 6ʰ and 7ʰ of R. A., and about 5° of declination. Here it amounts to 5.94, showing that there are eighty-six stars of magnitude 9.0 to every one of magnitude 6.5.

The D. M. does not stop at magnitude 9, as the above numbers do, but extends to 9.5, while the S. D. extends to magnitude 10. For these magnitudes Seeliger finds a yet higher ratio. This is, however, to be attributed to the personal equation of the observers, and need not be further considered.

The only available material for finding the ratio of increase above the ninth magnitude is found in the Potsdam photographs for the international chart of the heavens, which extend to magnitude 11. These are published only for a few special regions. Five of the published plates fall in regions not far from the galactic pole. I have made a count by magnitudes of the 312 stars contained in these plates. An adjustment is, however, necessary from the fact that the minuter fractions of a magnitude could not be precisely determined from the photographed images. The results are practically given to fourths of a magnitude, although expressed in tenths. But it is found that the numbers corresponding to round magnitudes and their halves are disproportionately more frequent than those corresponding to the intermediate fourths. For example, there are only nineteen stars of magnitude 10.7 and 10.8 taken together; while there are forty-nine of 10.5. Under these circumstances I have made an adjustment to half magnitudes by taking the stars of quarter magnitudes, and dividing them between half magnitudes next higher and next lower. The result is as follows:

Mag.	Stars.
6.5	2
7.0	2
7.5	4
8.0	11
8.5	15
9.0	29

Mag.	Stars.
9.5	33
10.0	39
10.5	64
11.0	115

It is difficult to derive a precise value of the star ratio from this table, owing to the small number of stars of the brighter magnitudes which are insufficient to form the first term of the ratio. Assuming, however, that the ratio is otherwise satisfactorily determined up to the ninth magnitude, we find that there is but a slight increase from the ninth up to the tenth. The number of the eleventh magnitude is, however, nearly three times that of the tenth and nearly double that of 10.5.

Another way to consider the subject is to compare the total number of stars of the fainter magnitude with the number of lucid stars corresponding, which, in the general average, will be found in the same space. We may assume that near the poles of the galaxy there is about one lucid star to every ten square degrees. The five belts included in the above statement cover about thirteen square degrees. The region is, therefore, that which would contain about one star of the sixth magnitude. An increase of this number by somewhat more than 100 times in the five steps from the sixth magnitude to the eleventh, would indicate a ratio somewhat less than 3; about 2.5. But the comparison of the photographic and visual magnitudes renders this estimate somewhat doubtful. Besides this, it is questionable whether we should not reckon among stars of the eleventh magnitude those up to 11.5, which would greatly increase the number. It is a little uncertain whether we should regard the limit of magnitude on the Potsdam plates as 11.0 or 11 plus some fraction near to one-half.

Altogether, our general conclusion must be that up to the eleventh magnitude there is no marked falling off in the ratio of increase, even near the poles of the galaxy.

I have not made a corresponding count for the galactic region, but the great number of stars given on the plate show, as we might expect, that there is no diminution in the ratio of increase.

The question where the series begins to fall away is, therefore, still an undecided one, and must remain so until a very exact count is made of the photographs taken by the international photographic chart of the heavens, or of the Harvard photographs.

There is also a possibility of applying a photometric study of the sky to the question. From what has already been shown of the total amount of light received from stars of the smaller magnitudes, it would seem certain that a considerable fraction of the apparently smooth and uniform light of the nightly sky may come from these countless telescopic stars, even perhaps from those which are not found on the most

delicate photographs. It is certain that the background of the sky itself is by no means black. The only question is, whether the light from this background is mostly reflected by our atmosphere from the stars. It may seem questionable whether such is the case, because the fraction reflected in a clear atmosphere is not supposed to exceed one-tenth the total amount of light of the stars themselves. On the other hand, the seemingly blue color of the sky might seem to militate against this view, since the average color of all the stars is white rather than blue. The subject is an extremely interesting one and requires further investigation before a definitive conclusion can be reached.

A CENTURY OF THE STUDY OF METEORITES.

By Dr. OLIVER C. FARRINGTON,
CURATOR OF GEOLOGY, FIELD COLUMBIAN MUSEUM.

THE close of the nineteenth century will mark the end of the first century of the study of meteorites. Up to the beginning of this century the attitude of scientific men toward the accounts of stones reported to have fallen from the sky was in general one of scorn and incredulity. Thus an account prepared with great care by the municipality of Juillac, France, telling of a stone shower which occurred there in July, 1790, was characterized by Berthelon at the time as "a recital, evidently false, of a phenomenon physically impossible" and "calculated to excite the pity not only of physicists but of all reasonable people." Bonn, in his Lithophylacium Bonnianum, refers to the Tabor, Bohemia, meteorite which fell in 1753, as "e coelo pluvisse creduliores quidam asseverant." Chladni, writing in the early part of the century, speaks of many meteorites which were thrown away in his day because the directors of museums were ashamed to exhibit stones reported to have fallen from the sky. President Jefferson when told that Professors Silliman and Kingsley had described a shower of stones as having taken place at Weston, Conn., in 1807, said: "It is easier to believe that two Yankee professors will lie than to believe that stones will fall from heaven."

The change of opinion on the part of intelligent and especially scientific men, which took place at the beginning of this century, was due largely to the investigation by the French Academy of the shower of stones which fell at L'Aigle in 1803. This investigation established so absolutely the fact of the fall to the earth at L'Aigle of stones from outer space that scientific men were logically compelled to give credence to the reports of similar occurrences elsewhere. Further, the papers of Chladni and Howard published about the same time, strenuously urging that other masses reported to have fallen upon the earth could not, because of their structure and composition, be of terrestrial origin, had much to do with fixing the growing faith that solid cosmic matter not of terrestrial origin does at intervals come to the earth. Since this beginning the study of meteorites has been one of constantly widening interest and purport.

The essentially distinguishing features of meteorites were early made out. Howard in 1802, from a chemical investigation of various "stony and metallic substances which at different times are said to have

fallen on the earth, also of various kinds of native iron," drew the conclusion that a content of nickel characterized most such bodies. He also found that the meteoric stones were made up chiefly of silica and magnesia and that the iron sulphide of meteorites was distinct from the terrestrial mineral pyrite. He further noted the chondritic structure as characteristic of many of the meteoric stones. The correctness of his observations was soon confirmed by analyses made by Fourcroy, John, Klaproth and others. In 1808 Alois von Widmanstätten, by heating a section of the Agram iron, brought out the figures which have since proved so characteristic of meteoric irons in general and which are now known by his name. Thus the data were early at hand for distinguishing meteorites from terrestrial bodies and it soon became possible to collect the 'sky stones' even when they had not been seen to fall. Systematic efforts for the collection of these bodies were not put forth, however, for many years. Up to 1835 there were only fifty-six different meteorite falls represented in the Vienna collection, and in 1856 only one hundred and thirty-six. Up to 1860 those of the British Museum collection numbered only sixty-eight and those of the Paris collection only sixty-four. The studies of these bodies during the first half of the century were made, therefore, upon a relatively limited number. The earlier investigations were chiefly chemical in character, various elements being discovered in succession. Manganese was discovered in the stone of Siena by Klaproth in 1803, chromium in the stone of Vago by Laugier in 1806, carbon in that of Alais by Thenard in 1808, chlorine in that of Stannern by Scheerer in the same year and cobalt by John in the Pallas iron in 1817. The number of elements discovered since has brought the total up to twenty-nine, none being found, however, which are not already known upon the earth. Many of the chemical compounds of meteorites were early isolated and their identity with terrestrial minerals established. Count Bournon showed in 1802 that the transparent green mineral accompanying the iron of Krasnojarsk was olivine. The same mineral was found in other meteorites by later observers, and Rose was able in 1825 to make angular measurements of the crystals which showed them to be identical with those of terrestrial olivine. Laugier separated chromite from the stones of Ensisheim and L'Aigle in 1806. Augite was recognized by Mohs in the stone of Stannern in 1824 and by Rose in that of Juvinas in 1825. Haüy recognized a feldspar which he thought to be orthoclase in the stone of Juvinas in 1822, but three years later Rose showed it to be plagioclase; and the existence of orthoclase in meteorites has yet to be proved. Continued investigations of the compounds found in meteorites up to the present time have resulted in the detection of at least twenty-one whose composition is certain, besides several of a somewhat problematic nature. Of these compounds seven have been

found to differ in composition from any known terrestrial substances. The character of these indicates the complete absence of water and of oxygen in any large amount from that portion of nature's laboratory where meteorites are formed. Important investigations as to the gases occluded by meteorites were begun by Boussingault in 1861 and have been continued by Wright, Ansdell, Dewar and others. It has been proved that large quantities of hydrogen, as well as carbonic acid gas, are contained in these bodies, under pressure greater than that of the earth's atmosphere. These investigations led further to the spectroscopic study of meteorites by Vogel, Wright and Lockyer. The spectra thus obtained when compared with those exhibited by comets showed striking resemblances, which have led to a growing belief among scientific men in the identity of origin of comets and meteorites. Lockyer has indeed pushed this conclusion to the point of believing that "all self-luminous bodies in the celestial spaces are composed either of swarms of meteorites or of masses of meteoritic vapor produced by heat," and he draws from this many important deductions relating to the origin of the stars, comets and nebulæ, and the physical conditions prevailing in them. It will remain for the twentieth century to test the correctness of such conclusions, but the facts already brought out have considerably shaken the confidence hitherto placed in the nebular hypothesis. Another interesting result of the century has been the establishment of a general similarity between shooting stars and meteorites. This idea was first suggested by Chladni in 1798, but it has remained for Newton, Adams and Schiaparelli to give it shape and proof. The general verdict of science is now in accord with the belief of Newton, "that from the faintest shooting star to the largest stone meteor we pass by such small gradations that no clear dividing lines can separate them into classes." Moreover, the long-existing belief in *le vide planétaire*, space filled only with a mysterious fluid called ether, has been shown to be untenable. Careful records and estimates have shown that 20,000,000 cosmic bodies large enough to produce the phenomena of shooting stars are encountered by the earth daily. The number of these bodies existing in space must be, therefore, beyond all calculation, and their existence implies that of smaller particles in sufficient number to form a widely pervasive cosmic dust. Many remarkable meteorite falls have occurred during the century. Beginning with the stone shower of L'Aigle in 1803, when 2,000 to 3,000 stones fell, no less than eleven such showers have been recorded. In the shower of Pultusk, Poland, which occurred in 1868, 100,000 stones are estimated to have fallen, their total weight reaching over 400 pounds. In the shower at Mocs, Germany, in 1882, more than 3,000 stones fell. In our own country about 750 pounds of meteoric matter fell at Estherville, Iowa, in 1879, and several thousand stones fell over an area nine miles in

length and one mile wide near Forest City, Iowa, in 1890. Many of these falls have been marked by extraordinary phenomena of light and sound, making them events never to be forgotten by those who witnessed them and worthy to be reckoned among the most remarkable natural occurrences of the century. About two hundred and eighty-five actually observed meteoric falls is the total recorded during the century. It is a remarkable fact regarding the nature of the material fallen that only five of these have been of meteoric irons. One of these irons fell at Mazapil, Mexico, during the star shower of November, 1885, at the time when the return of Biela's comet was looked for, and was thus considered an occurrence corroborative of the already suspected relationship among comets, shooting stars and meteorites.

The indifference to the collecting of meteorites which characterized the early part of the century has given place in its latter days to an extraordinary diligence in the search for these bodies. One meteorite has of late acquired a value equal to four times its weight in gold and several can be sold for two and three times their weight by the gold standard. The meteorite collection of the Natural History Museum in Vienna has for many years been the leading one. What it has cost to build it up may be known from the fact that it is considered the most valuable of any single collection in that great treasure house. Representatives of over five hundred meteoric falls are exhibited in this collection, and the meteoric matter has a total weight of seven tons. The collection of the British Museum of Natural History is nearly as large, while at Paris, Berlin, St. Petersburg and Calcutta, together with Washington, Chicago, Cambridge and New Haven, in our own country, are gathered extensive and important collections. The establishment of such large collections has for the first time put the study of meteorites on a satisfactory basis and given lively hope that important truths will be discovered by researches thus made possible. The general similarity of the stony meteorites to the basic volcanic rocks of the earth has been established, and similarity of many physical structures such as brecciation, slicken-sided surfaces and veins has been proved. The chondritic structure and the crystalline structure represented by the Widmanstätten figures are, however, so far as is yet known, peculiar to meteorites, and it will remain for the twentieth century to discover what these structures mean. Classifications of meteorites based on their mineralogical and structural characters have been established, and important differences among meteorites shown, in spite of their family resemblances. It would be idle perhaps to recount, as might be done, many theories regarding the nature and origin of meteorites which have been found untenable as a result of the century's study. The theory of the lunar origin of meteorites had at times such able supporters as Laplace and J. Lawrence Smith. Other able observers have believed

meteorites to be material ejected at some past period from the earth's volcanoes; some have regarded them of solar origin and still others as fragments of a shattered planet. All of these theories may be said to have been proved fallacious. The discovery reported by Hahn in 1880 of remains of sponges, corals and plants in meteorites excited for a time eager inquiries into the possibilities of proving by the study of meteorites the existence of life outside our own globe. No satisfactory evidence of the existence of extra-terrestrial life has, however, as yet been obtained from meteorites. The most positive and enduring results of the century's study may, therefore, perhaps be summed up as the establishment of the fact of the fall of solid cosmic matter to the earth and a sufficient knowledge of its nature to distinguish it from matter of terrestrial origin. Satisfactory conclusions as to the origin of this matter and its relations to the visible bodies of the great outlying universe remain yet to be drawn.

DISCUSSION AND CORRESPONDENCE.

A DEFENSE OF CHRISTIAN SCIENCE.

To the Editor: You informed me in my recent interview with you that discussions of a religious nature did not come within the scope of the purpose of your magazine. I am convinced by your fair, frank and kindly manner that you are unaware of the injustice done a large class of thinking people and many readers of your magazine by the article in question between us written by Professor Jastrow and published in the September number of the POPULAR SCIENCE MONTHLY. Nevertheless a great injustice has been done in that you have, even inadvertently, allowed a religious movement to be attacked through the press, while the rules of your publication allow no redress. This seems neither in consonance with justice, free speech nor a free press; and now accepting the situation as no motive or act of yours, and inasmuch as you must refuse to publish an article defending Christian Science, unless the said article be written wholly from a scientific viewpoint, excluding scriptural basis and argument; and inasmuch as Christian Science is not merely a philosophy but a science, having for its principle God, for its textbook the Scriptures and for its proof the moral, spiritual and physical betterment of thousands of its adherents; and inasmuch as the philosophy, works and phenomena of Christian Science can only be discussed or understood from a Christianly scientific standpoint based on the Scriptures, and not from the standpoint of so-called material science or from any hypothesis of a universe without a creator, who is omniscience (all science), and who, therefore, governs His creation with spiritually scientific, not material, law; and inasmuch as that compilation which our race and nation call the Bible, and believe to be a revelation from God as well as ancient history; inasmuch as this book with its key alone unlocks and reveals the consistent beauty, grandeur, might and majesty of spiritual law or science which the world cannot see, does not understand, and the 'wise' call foolish and inconsistent.—Considering all these points and conceding them—because you cannot deny from an opposite premise what I find true—and now, my dear sir, I will ask you to publish this, my letter to you, and a few remarks on Professor Jastrow's article, 'The Occult.'

To begin with, let it be understood that in very fact Professor Jastrow did not attack Christian Science at all. He thought he did, and was no doubt perfectly honest in decrying a thing so occult and wrong as what he believed Christian Science to be; and were it such a thing I would join issue with our critic against it—but behold the fact: Christian Science is as far above what Professor Jastrow attacked in the 'occult' as the science of astronomy is above 'tiddledewinks.'

Professor Jastrow says: "Logic is the language of science. Christian Science and what sane men call science cannot communicate, because they do not speak the same language." Here the Professor, a material scientist, confesses profound ignorance of our spiritual premises, yet sits in judgment on mentally scientific and metaphysical statements in *Science and Health*, vilifies the science and calls its votaries insane. Such a position makes our critic's logic lame. Surely, Professor Jastrow must be cognizant of the fact that very many, as erudite as he, swell the ever-increasing ranks of scientific

Christianity; and in face of these facts his position, to say the least, seems unfair and unkind.

The statement that Dr. Quimby practised Christian Science or that his mental method contained some of the essentials of Christian Science accounts for the further assertion that Christian Science is not Christian. Professor Jastrow deserves credit for discerning that Dr. Quimby's methods were adverse to Christ's teachings, but just how the good Professor determines the finality of what has defied eighteen centuries of time and scholastic theology is a mystery; to wit: the Doctrine of Christ. Why, ages have wrangled and fought over this subject until history points with scarlet finger to unchristly deeds and impotent creeds, all in His name; and even yet the lack of unity among Christian denominations and the utter want of that power and glory which characterized the founder of Christianity and the early Christians puts to shame the theological labor of the centuries.

Professor Jastrow is not an authority on Christianity, yet he pronounces Christian Science unchristian. Let me quote some authority on this subject: Rev. Edward T. Hiscox, D. D., of Brooklyn, in the *Christian Enquirer*, a Baptist organ, says: "The modern Church would be elevated to a much higher plane of Christian living than it now occupies if it were to follow them. I am profoundly convinced that the great need of all our churches is more of the religion I have seen in the lives of the Christian Scientists whom I know." Rev. Dr. E. C. Bowls, of New York City, President of the State Convention of Universalist Ministers, in speaking of Christian Science, says: "There is certainly a perception here of the true foundation of Christianity." I might quote from Phillips Brooks and many theologians of like note, but *quantum sufficit*. Who will venture to assert in face of the evidence given that Professor Jastrow's argument on this point has any force at all?

Professor Jastrow also says Christian Science is not a science, and that Materia Medica is a science. This first assertion is most wanting in reason or proof, for if Christianity is not scientific it is not true. Anything which has a demonstrable principle is said to be science. If Christianity lacks a principle, it is nothing but theory or belief; on the other hand, if the Christian religion has a principle, it is a scientific religion or a Christian science. The second assertion that Materia Medica is a science challenges the wisdom of experienced men who are authority on this subject, while Professor Jastrow is not. The 'Standard Dictionary' says of Materia Medica: 'It is the most empirical and tentative of all sciences.' Many eminent medical teachers and practitioners do not agree with Professor Jastrow's views on Materia Medica. Of these I will mention Dr. Rush, the famous Philadelphia teacher of medical practise; Dr. Waterhouse, Professor in Harvard University; Dr. Mason Good, a learned professor in London; Dr. Chapman, Professor of the Institutes and Practise of Physics in the University of Pennsylvania. Sir John Forbes, M. D., F. R. S., Fellow of the Royal College of Physicians of London, says: "No systematic or theoretical classification of diseases that therapeutic science has ever promulgated is true or anything like the truth, and none can be adopted as a safe guidance to the practise."

The above is to show the weakness of Professor Jastrow's argument, and not to depreciate the philanthropic efforts and labor of the noble multitude of M.D.'s who have alleviated much suffering and done much good in the world. We honor them for the noble lives and the good they have done and are still doing.

Professor Jastrow is no doubt a very clever and very learned man, but he has not proved himself capable of classifying the sciences nor of sitting in judgment on Christianity.

Mr. Jastrow acknowledged 'the pop-

ular preeminence of Christian Science' and advises reading *Science and Health*. Truth courts investigation, and when *Science and Health* is universally read, its abstract and metaphysical statements will be found simple compared with the tangled verbosity of human reason and human logic.

Logic is, indeed, the language of science, but scientific fact is based on principle, and principle—call it what you will, but I call it God.

J. EDWARD SMITH.

[Professor Jastrow's article on 'The Modern Occult,' published in the September number of the POPULAR SCIENCE MONTHLY, has not unnaturally called forth a number of replies. As there seems to be some fairness in the claim of the 'Christian Scientists' that a sect counting its adherents by hundreds of thousands should be heard in its defense, and as Mr. Smith appears to have been delegated to make an official reply and has consented to do so briefly, we have pleasure in publishing his letter. It will be read with interest by many, and will undoubtedly confirm Professor Jastrow's statement that argument is impossible when people do not speak the same language. From the remote past men have worshiped strange gods in strange ways, and that there should be survivals and avatisms is in nowise surprising. We are not concerned with these, but when a religious sect trespasses on the domain of science it must be treated in accordance with due process of law. The Christian Scientists in their claims to treat all manner of disease have laid themselves open, not only to the charge of folly, but also of charlatanism. The writer of the above letter offered to produce before the editor of this journal a number of persons who had been cured of snake bites by Christian Science treatment. As people almost never die from bites of American snakes, and as there is no reason in this case why the Christian Science treatment should kill them, the production of the survivors was not a matter of scientific interest. It was, however, suggested to the gentleman that he permit himself to be a subject for inoculation experiments with snake venom, as his assurance that he could not be poisoned would in nowise interfere with the scientific results. To this proposal, however, he did not take kindly. It is on record that Mrs. Eddy not only suffered from toothache but took nitrous oxide gas when the teeth were extracted. But the inconsistencies of the leaders of Christian Science make no impression on its adherents. We do not speak the same language.—EDITOR.]

MR. TESLA'S SCIENCE.

To the Editor: In the *New York Sun* for January 3, Mr. Nikola Tesla has an article that deserves a word. The word is one of warning to all sober-minded readers to remind them that Mr. Tesla's recently published utterances have discredited him in the eyes of competent judges. In the *Century Magazine* for June, 1900, Mr. Tesla printed a long article, superbly illustrated with cuts that had little or nothing to do with his subjects, which dealt with a few electrical matters, and also with philosophic and social problems upon which he freely expressed a jumble of trivial, ignorant, pretentious and erroneous opinions. This article was freely reviewed in the POPULAR SCIENCE MONTHLY for July, 1900, and in *Science* for September 21. These reviews were doubtless seen by Mr. Tesla, but no word of reply has been made public by him. Indeed, he says in the *Sun* that from adverse criticisms on his work he experiences 'a feeling of satisfaction.' Any one who desires a standing among men of science is called upon to defend his public utterances when they have been seriously questioned in reputable scientific journals. Until an adequate rejoinder is received Mr. Tesla has no standing among professed men of science. He will have none among intelligent readers from the moment that the case is understood by them. It is not

profitable to again go over the ground covered by the articles just mentioned, but readers are referred to them in passing.

The article in the *Sun* of January 3 bears the marks of authenticity. Much of it is printed in quotation marks. It gives an account of Mr. Tesla's work in Colorado during a part of the year 1899. This work had, he says, three objects: first, to transmit power without wires, and second, to develop apparatus for submarine telegraphy. These two problems have a direct commercial value. When they are solved, by Mr. Tesla or another, we shall hear of them through the Patent Office. As we have not so heard of them it is permissible to wait for results. We wish Mr. Tesla every success in these investigations. He is entitled to all the time he needs—a lifetime if necessary. If his experiments forward our present knowledge in any material degree he will be entitled to the gratitude of all mankind, and he will receive it. Until they do pronunciamentos from him and comments from us are not required.

The third problem upon which Mr. Tesla was engaged 'involves,' he says, 'a still greater mastery of electrical forces.' He will 'make it known in due course.' In the meanwhile, however, he states that he has noted "certain feeble electrical disturbances . . . . which by their character unmistakably showed that they were neither of solar origin nor produced by any causes known to me on the globe." These he supposes may have been signals from intelligent beings on Mars or some other of the 'twenty or twenty-five planets of the solar system.' Mr. Tesla obviously wants to figure in the newspapers. Every one would be greatly interested if it were true that signals are being sent from Mars. Unfortunately for Mr. Tesla's scientific standing, he has not adduced a scrap of evidence to prove it. It is of a piece with the 'twenty or twenty-five planets' he ascribes to the solar system. It would be interesting if there were so many. There is no evidence of it save Mr. Tesla's assertion, and assertions—Mr. Tesla's or another's—do not count in science. There is no further space for a notice of Mr. Tesla's latest extravagant vagary. For men of science no notice at all is needed. Any intelligent reader who will consult the reviews already mentioned and compare them with Mr. Tesla's own words will see that his vivid writings must be read with extreme caution. His electrical experiments being directed towards commercial uses must be judged by proved commercial success. His speculations on science are so reckless as to lose an interest. His philosophizing is so ignorant as to be worthless. X.

SCIENTIFIC LITERATURE.

ENGINEERING.

AMERICAN books on surveying have heretofore been prepared primarily as texts for class use, rather than for the use of the field engineer. This point of view is reversed in the volume of 900 pages, by Herbert M. Wilson, entitled 'Topographic Surveying, including Geographic, Exploratory and Military Mapping,' recently issued by John Wiley & Sons. It sets forth, in the main, the practise of the U. S. Geological Survey, and many of the illustrations have been derived from the publications of that bureau, the colored ones being printed from copper plates owned by the Government. Field work, with the plane table, the transit and stadia, the level and office methods of mapping occupy nearly one-half of the volume; about 300 pages are devoted to geology and astronomy, and the remainder to photography, camping, and the subsistence and health of field parties. In no book heretofore issued are the practical details of topographic work discussed with such fulness as here, and the numerous tables will be found of great assistance in facilitating computations. Indeed, a special effort seems to have been made in the direction of tables, some of which might well have been omitted; for instance, the space devoted to the table of Peirce's criterion for the rejection of observations would have been better filled by elementary matter on the method of least squares, and the table for the values of $0.046d$, when d=10, 20, 30, etc., seems a reflection on the mathematical knowledge of the reader. The book is in general clearly written, although the frequent use of italics seems to indicate that the author was often apprehensive that he might be misunderstood. It is a valuable supplement to the text-books of the engineering colleges.

'ROAD MAKING AND MAINTENANCE,' by Thomas Aitken (London, Griffin & Co.), deals largely with European practise in street construction. The country roads of England are as a rule better than those of the United States, having been earlier built and more systematically repaired, while great attention is paid to securing uniformity of surface. An instrument called the viagraph is described by the author, which takes an automatic record of the inequalities of the street surface and gives the sum of all the vertical depressions found in paving over a mile. A road having 15 feet of such depressions per mile is called excellent, while a fair road has 40 or 50 feet per mile, and a passable one 60 or 80 feet per mile. The cost of this viagraph is moderate, and it is only necessary to drag it along the street in order to obtain the authentic record. It is surprising to learn that wooden pavements still continue to be laid in English towns, while brick pavements are practically untried. On questions of city streets American practise seems fully abreast of that of England now that the necessity of good foundations of concrete is fully recognized. 'Street Pavements and Paving Materials,' by George W. Tillson (New York, Wiley & Sons), sets forth modern American practise in an exhaustive manner, giving specifications in use in different cities for different kinds of pavements. The first asphalt pavement laid in the United States was in 1870; great difficulties were met in adapting asphalt to climate and traffic, but these have

gradually been overcome, and to-day we have hundreds of miles of these excellent pavements. The first brick pavement of the United States was also laid in 1870, and to-day the total number of miles is nearly a thousand, of which more than one-tenth are in Philadelphia. The cost of road construction and street paving appears to be now slightly less in the United States than in England, and hence there is little doubt but that in another half century our roads and streets will be brought into a condition fully equal to that found in Europe. These two books show that road building can no longer be left to farmers, and street construction to town councilmen, but that economic results can only be secured when they are placed under the charge of experienced civil engineers.

'IRRIGATION AND DRAINAGE,' by F. H. King, published by the Macmillan Company, is not strictly an engineering book, it having been mainly prepared for the farmer and gardener, but it is difficult to find a technical work which so clearly exemplifies the fundamental principles and minor details of the subject. The conditions that make irrigation imperative or desirable, the proper amount of water to be used, the methods of supplying and distributing the water, the laws of flow of ground water, and the reasons, objects and methods of draining land are set forth in a correct and lucid manner. As a text-book for use in agricultural colleges the volume appears to be well adapted, while engineering students will find that its discussions throw new light on their view of the subject. The irrigation of the arid regions, formerly known as the Great American Desert, is now a matter of great importance to both engineers and agriculturists, and the author deals fully with the peculiarities of its alkali soils and with the results thus far attained. In this connection note may be made of a recent Bulletin of the U. S. Geological Survey, entitled 'Storage of Water on Gila River, Arizona,' by J. B. Lippincott. This is a topographic and engineering study for an irrigation scheme made under a law authorizing that bureau to carry on surveys for possible reservoir sites in the arid regions. Powerful influences are at work to induce Congress to appropriate money for the construction of such reservoirs and for building canals to deliver water to irrigable areas. On the Gila River watershed it has been found that several reservoir sites are available, that the Buttes dam may be built at a cost of $2,600,000, the San Carlos dam at a cost of $1,039,000, and others for smaller amounts. It is gravely urged in this Bulletin that the Government should build one of these dams, in order to accommodate certain Indians from whom white men have already diverted water to which the tribe has a legal right. As these lines are written an effort is being made to push this philanthropic scheme through Congress by means of an amendment to the River and Harbor bill!

THE literature of engineering now covers so vast a field that a person can become acquainted only with a part of the portion relating to his specialty Catalogues and indexes are indispensable, in order that he may know what has been printed and where to find it. The 'Catalogue of the Library of the American Society of Civil Engineers' is a valuable aid in this direction, although that library is far from complete. This volume, which contains seven hundred and four closely printed pages, arranges the books and pamphlets under twenty-five principal classes, each of which is divided into several sub-classes, thus rendering it easy for the engineer to ascertain exactly what the library contains on any topic. This method of arrangement has decided advantages over the usual author and subject catalogues of books whose publication is rarely advisable. The engineering literature in periodicals is, however, not represented in this catalogue, except in the titles of the journals. A 'General Index to En-

gineering News from 1890 to 1899' has just been issued, which supplies the want as far as the files of that journal for those years is concerned. This is a volume of three hundred and twenty-four pages, alphabetically arranged after the manner of a subject catalogue; it is an excellent example of good indexing, which may profitably be followed by other periodicals with advantage to themselves and their readers.

'WATER POWER,' by Joseph P. Frizell, published by Wiley & Sons, is the first engineering book to bear the date of the twentieth century. It is a book for the practitioner rather than for the student, practical rather than theoretical, descriptive rather than argumentative. Of the five hundred and sixty pages, about two hundred are devoted to dams, about one hundred and fifty to canals and water wheels, and the remainder to the construction of power plants and the transmission of power. Much of the extended experience of the author is here recorded in a form which is likely to be useful to the enginering profession, and it is certain that as the coal deposits become exhausted the energy of waterfalls must more and more be utilized. It was a marked characteristic of the engineering books of the nineteenth century that they were adapted for the use both of students and practitioners, the same works that were studied in the classroom being the manuals for field and office work. There now seems to be a tendency to issue books, embodying the experience of engineers, which are mainly useful in practise and which are needed in engineering colleges only for consultation. One reason for this is that the number of engineers is now so great that such books can be published with profit, and another is that many details of practise have become so systematized that scientific classification of them is now possible. The economic side of engineering practise has, in fact, become of utmost importance, and the multiplication of books and periodicals is necessary in order that each designer may see the good points of the designs of others, avoid their faults, and thus make his own construction of greatest stability and usefulness at the minimum cost.

MYCOLOGY.

A BOOK on 'Edible and Poisonous Mushrooms,' by Prof. George F. Atkinson, of Cornell University, has been published by Andrus & Church, Ithaca, N. Y. The author's 'Studies and Illustrations of Mushrooms,' issued as Bulletins 138 and 168 of the Cornell University Agricultural Experiment Station, have been so well received, and there has been such a demand for literature on the subject, that he prepared this large octavo book, containing over two hundred half-tone illustrations. Of these, seventy are used as full-page plates, and there are, besides, fifteen species in color. Nearly all the genera of North American agarics are illustrated, and many of the important genera, such as *Amanita*, *Agaricus (Psalliota)*, *Lepiota*, *Mycena*, *Paxillus*, etc., have a number of illustrations, while the genus *Amanita*, containing several of the most poisonous species, represented by about fifteen species, fully illustrated with the development and differential characters, described at length. In all, about two hundred species are described, and more than three hundred names are accounted for. Mrs. Sarah Tyson Rorer writes a special chapter on recipes for cooking mushrooms, and Mr. J. F. Clark one on the chemistry, toxicology and food value of mushrooms. There are also chapters on the collection and preservation of mushrooms, how to avoid the poisonous ones, and keys to the genera of the agarics.

FOLK-LORE.

IN the 'History of the Devil and the Idea of Evil from the Earliest Times to the Present Day' (The Open Court Publishing Company), Dr. Paul Carus has produced an interesting and a convenient manual of a certain aspect of the an-

thropological history of religions, and of certain of the moral conceptions and the aids to their realization which these religions embody. The scope of the work is more various than the title would suggest, for it includes the consideration of the outlying topics that are indirectly but not inherently connected with the idea of evil and its personal embodiment. It thus loses in its systematic character, but gains somewhat in its acceptability as a popular presentation. The author has made good use of the extensive literature of his special topic and of the themes with which it is associated; but the compilation can not and presumably does not lay claim to any marked originality of contribution or presentation. In one aspect the volume shows commendable industry, namely, in the collection of illustrations, which give an unusually realistic account of the vagaries of the human mind, and especially the human imagination, in dealing with the mystery of good and evil. In five hundred pages of text we have three hundred illustrations, ranging from savage and Assyrian and Chaldean and Egyptian and Classic and Medieval and modern pictures of the incarnation of evil, to the acts of sacrifice and worship instituted in his honor, to Faust legends and the fate of the damned, to demon-possession and exorcism, to the scenes at the stake and the persecution of witches, to the portrayal of the devil in art and literature, in folk-lore, and finally his degradation in the caricature and drama of the day. This panoramic unfoldment of the changes of attitude towards the monarch of evil affords an interesting corollary to the conquests of culture over the terrifying realms of the imagination. The flight to evil that we know not of has in all ages been made by the fancy of the religious devotee, the ascetic, the churchman, and through them as well as by reason of the inherent necessity for a fear of consequences as an incentive to moral action, has the devil continued to live and exert his influence over the affairs of men. "The Devil of the Salvation Army," says Dr. Carus, "proves that there is still need of representing spiritual ideas in drastic allegories; but though Satan is still painted in glaring colors, he has become harmless and will inaugurate no more witch-persecutions. He is curbed and caged so that he can do no more mischief. We smile at him as we do at a tiger behind the bars in a zoological garden."

The scope of the work may be briefly indicated. An introductory consideration of the nature of good and evil as religious ideas leads to a general account of demonolatry; this cult and its various expressions in ancient Egypt, in Persia, among the Jews, in Brahmanism and Buddhism, are then described; the new era introduced by the spread of Christian conceptions is portrayed, and its combination with the conceptions of Greece and Rome, its later encounter with the traditions of Northern mythology are further characterized; the successive periods of inquisition, witch-persecutions, reformation, constitute the zenith of the diabolical epoch; the reconstruction of the notions in regard to Satan is well illustrated in the literature, while the philosophical problem of good and evil still remains for discussion, even after science and the progress of civilization have crowded the personal devil out of his occupation.

The main value of this volume is the service which it is capable of performing as a work of reference, and again as an interesting presentation of a range of ideas with which many scholars with various purposes have to deal, and which forms a significant chapter in the history of culture.

THE PROGRESS OF SCIENCE.

CRITICISM of the Government is a cherished prerogative of a democratic people. Shortcomings that would be regarded as inevitable in the conduct of a private institution, when discovered under Government control, are apt to be the target of very free speech. We believe that the scientific work at Washington is, on the whole, carried on as economically and efficiently as in our endowed universities, but no human institution is perfect, and just now the U. S. Naval Observatory is being subjected to a good deal of criticism by the astronomers of the country. There is a general consensus of opinion that, while researches and discoveries of the highest order have been made at the Naval Observatory, there has been a lack of the far-reaching and long-continued fundamental work which should be the chief end of a national institution of this character. It is also pretty generally agreed that one chief difficulty is the division of control, the Observatory having for superintendent a line officer of the Navy, with no knowledge of astronomy and a scientific director with no real authority. Last year a board of visitors was appointed by Secretary Long, consisting of the Hon. William E. Chandler, the Hon. Alston G. Dayton, Prof. E. C. Pickering, Prof. George C. Comstock and Prof. George E. Hale, who made a careful report, their chief recommendation being that the Observatory be under the control of a permanent board of visitors, who should prescribe the work to be undertaken and fill vacancies on the staff, the astronomers so appointed to be no longer officers of the Navy. The naval officer who happens to be superintendent of the Observatory has just now made a rather acrimonious reply to the report of the board of visitors, calling its recommendations 'preposterous' and 'ridiculous,' and maintaining that the work done at Washington is equal to that of the Greenwich Observatory.

IT must be confessed that there is small likelihood that the recommendations of the board of visitors will be carried into effect. The naval officers at Washington have great and well-deserved influence, and they must be persuaded either to consent to the transfer of the Observatory to another department or else to conduct the institution under the Navy in the way that will be most creditable to it and to the country. We regard the latter alternative as the more feasible. There may ultimately be a national department of education and science with a secretary in the cabinet, but the time for this has not yet come. In the meanwhile scientific work is distributed to different departments, and the Department of the Navy can conduct the Observatory, as is the case in Great Britain and France, as well as another department, even though the work of the Observatory and the Nautical Almanac are not exclusively, and perhaps not chiefly, of concern to the Navy. The stars—so long as they are not annexed—may logically belong to the department having to do with foreign affairs, but in this world logic is of less concern than making the best of existing circumstances. What we regard as essential is to convince the Department and the officers of the Navy that there should be a single head of the Observatory, selected as the man most competent by scientific attainments and executive ability to administer the institution. The promotion of the officer longest in the service to the scientific directorship and his retirement at the age of sixty-two years will certainly

not always secure the best man possible or for a sufficiently long term of years. The director of the Observatory should be appointed by the President, on the recommendation of the Secretary of the Navy, and the latter should select one of two or three candidates nominated by some expert body such as the National Academy of Sciences. If such a plan were properly brought before the Secretary of the Navy, we believe that it would secure his approval and also the support of the officers of the Navy, who take pride in the Observatory. They would also probably agree that it would be more appropriate to change the name from 'Naval' to 'National' Observatory, it being administered by the Navy for the Nation.

THE scientific students of the country have two general gatherings in the course of the year. In the summer the American Association for the Advancement of Science holds a migratory meeting, and with it assemble a number of special societies. During the Christmas holidays the American Society of Naturalists serves as a center for societies devoted to the natural sciences—morphology, physiology, anatomy, bacteriology, botany, psychology and anthropology. The meetings of these societies were held this winter at the Johns Hopkins University, Baltimore, from the 26th to the 29th of December. There was no general registration of members, but the attendance was estimated at about three hundred, and as it consisted exclusively of working men of science, the number of papers presented was nearly equal to the attendance. The scientific work of the Society of Naturalists consists of a discussion on some subject of common interest, a lecture preceding the usual reception, and an address by the president, given at the annual dinner, while the special papers are presented to the groups of experts who make up the special societies. The discussion this year was on the relations of the Government to scientific research. It was opened by Prof. H. F. Osborn, of Columbia University, the American Museum of Natural History and the U. S. Geological Survey, who was followed by Prof. William B. Clark, of the Johns Hopkins University and the Maryland Geological Survey; Dr. L. O. Howard, Chief of the Division of Entomology of the U. S. Department of Agriculture; Dr. B. T. Galloway, Superintendent of Experimental Gardens and Grounds, U. S. Department of Agriculture, and Prof. William T. Sedgwick, of the Massachusetts Institute of Technology. The evening lecture on 'Indians of the Southwest,' elaborately illustrated, was given by Dr. Frank Russell, of Harvard University. The address of the president, Prof. E. B. Wilson, of Columbia University, was entitled 'Aims and Methods of Study in Natural History.' While the naturalists were meeting at Baltimore, the Geological Society of America held its thirteenth winter meeting at Albany, and the American Chemical Society held its twenty-second general meeting at Chicago. The American Physical Society and the American Mathematical Society held their sessions as usual in New York, while a branch of the latter society met at Chicago. There was also in Chicago a meeting of the Naturalists of the Western and Central States, with an attendance of one hundred members and a program containing about forty papers. The academies of a number of the Central and Western States, including Ohio, Iowa, Kansas, Wisconsin and Nebraska, also held their annual meetings. When it is stated that about five hundred scientific papers were presented before these societies, it will be seen how impossible it is to give a report of their great and far-reaching activity. We may, however, illustrate the character of their work by three or four examples.

As an example of the scientific work carried on by morphologists at the present time, we may note two important papers presented by Prof. E. B. Wilson, of Columbia University, at Baltimore. One of the most interesting biological results of recent years is the discovery

of Loeb that the eggs of the sea-urchin may be caused to develop, without the influence of the male element, by treatment with solutions of magnesium chloride or other substances added to the sea-water. Wilson has now examined the internal processes occurring in these eggs. Phenomena of this character had been earlier studied by Richard Hertwig and Morgan, whose work paved the way for that of Loeb; but neither of these observers succeeded in obtaining complete embryos, the eggs only having passed through the initial stages of development. Wilson's observations bring the decisive proof that the eggs, developed under these conditions, have not been accidentally fertilized. It is well known that in the fertilization of the egg an equal number of chromosomes are contributed by the egg and the spermatozoon, this number being in every known case one-half that characteristic of the tissue cells of the species. If, therefore, the magnesium eggs really develop without union with a spermatozoon, we should expect to find them showing but one-half the number of chromosomes occurring in fertilized eggs. Such is, in fact, the case in the magnesium eggs (of *Toxopneustes)*, the number of chromosomes being here 18, while in normal fertilization it is 18 plus 18, or 36. Every doubt is thus removed regarding the accuracy of Loeb's general result. Interesting light is thrown by the observations on many features of the process of normal fertilization. According to Boveri's well-known theory, the egg is induced to develop through the importation of a centrosome carried by the spermatozoon. In the magnesium eggs this is obviously out of the question; and Wilson's studies, supplementing the earlier ones of Hertwig and Morgan along the same lines, give strong evidence not only that the importation of a centrosome is not necessary to development, but also that the centrosomes of the dividing magnesium eggs are formed *de novo* out of the egg-substance. As observed by Morgan, these eggs often become filled with large numbers of asters, each of which contains a centrosome. One of the most interesting results of Wilson's work is the discovery that these asters may multiply by division and form centers of cytoplasmic division, even when they have no connection with nuclear material. The important point was determined also that similar asters and centrosomes, likewise capable of division, are formed in non-nucleated egg-fragments obtained by shaking the eggs to pieces—a fact which shows that the formation of a centrosome may be wholly independent of the nucleus.

In a second paper Wilson described experiments on etherizing normally fertilized eggs at various stages, the results of which bear nearly on some of the questions suggested by the magnesium eggs. The principal result of these experiments was to show that division of the nucleus and that of the cell-body, though parallel, are in considerable measure independent processes, which is in accordance with earlier studies by Hertwig, Demoor and others. The results give, further, considerable ground for the conclusion that the rays of the radiating systems or asters in dividing cells cannot be regarded as fixed, fibrillar structures, as is assumed by most of the prevailing views, but are tracts of protoplasmic flow, as was many years ago maintained by Fol and Bütschli. It was shown also that by suitable etherization of the eggs and subsequent transfer to sea-water, the type of fertilization characteristic of the sea-urchin may be artificially changed into that normally occurring in the starfish, and in many worms and mollusks; and, in like manner, that the cleavage of the egg may be transformed into a mode that is typical of many of the cœlenterates and arthropods. These observations show that many new and interesting conclusions bearing on the early stages of development may be looked for by further experimental studies along the lines marked out fourteen years ago by O. and R. Hertwig,

which have been too much neglected by later observers.

THE geologists were especially interested in a paper by Prof. Frank D. Adams, of McGill University, which gave the results of an investigation on the flow of rocks when subjected to pressure in the laboratory under conditions which reproduce those obtaining in the deeper portions of the earth's crust. Marble was the rock on which most of the work was carried out, but harder rocks, such as granite, are now being studied. Small columns of marble were carefully turned, polished and accurately fitted into heavy wrought iron tubes, constructed on the plan of heavy ordnance by wrapping strips of wrought iron around a core of soft iron and welding the whole together. The core of iron was then bored out and the marble substituted for it. Heavy steel pistons were fitted into each end of the tube, and the rock was submitted to very high pressure, often for several months continuously, in especially constructed machines capable of developing pressures reaching nearly a hundred tons to the square inch. Under high pressures the marble was found to flow, bulging out the iron tube that enclosed it on all sides. When the iron tube was cut away a solid block of marble was obtained, which had completely altered its shape. It was found, however, that the marble in these cases was only about half as strong as the original rock. Other columns of marble were heated to temperatures of 300° C. and 400° C., and while thus heated the pressure was applied as before. Under these conditions the rock was found to flow readily and to retain its strength much better, being nearly as strong as the original rock. In the third series of experiments, the marble was not only heated to the temperatures before mentioned, but at the same time water under a pressure of 460 pounds to the square inch was forced through it while it was being compressed. Under these conditions, the marble, after being molded, was found to be as strong as it was originally. A microscopical study of the structure of the deformed marble shows that in these two latter cases the crystalline grains composing the marble had glided on one another.

AMONG the papers presented before the Bacteriological Society one of the most interesting was by H. L. Russell and S. F. Babcock, of Madison, Wis., upon the causes effective in the production of silage. The very great influence of bacteria in natural processes has led in the last few years to an assumption on the part of bacteriologists that these micro-organisms are agents in nearly all the general processes of nature involving chemical change. Among other phenomena connected with agriculture, it has been claimed that the changes which take place in corn fodder in the farmer's silo are the result of the growth of bacteria. These changes are accompanied by a rapid heating of the material when first placed in the silo and, later, by the production of peculiar flavors and aromas. These phenomena are so similar to those which bacteria are known to produce that it has been a very natural assumption that they are caused by micro-organisms. Russell and Babcock have been of the opinion that bacteriologists have gone too far in ascribing natural phenomena to bacterial agencies, and that it is necessary to look in different directions for the explanation of some of them. The production of silage, for example, they insist, is not the result of bacterial action. By carefully performed experiments they succeeded in producing normal silage under conditions in which bacterial growth was prevented. They conclude that the changes occurring in silage are produced partly by a continuation of the respiratory activities of the plant cells, which, for a time, are stimulated rather than checked when the plants are cut to pieces for storing in the silage, and partly as the result of the action of certain chemical ferments or enzymes, which are eliminated

from the plant cells after the death of the plant. These two factors the authors regard as the efficient cause of these changes in silage which have hitherto been attributed to the growth of bacteria, and they believe that bacteria have nothing to do with the process when it takes place in a normal manner.

THE outcome of the experiments in growing Sumatra tobacco in the Connecticut Valley, recently reported by the National Department of Agriculture, is something more than a successful attempt at plant introduction. It is a tribute to the efficiency which has been attained in the methods of conducting soil survey, and a notable illustration of the scientific and practical value of such a survey as a basis for judging of the adaptation of agricultural plants. Two years ago the Division of Soils, in connection with its soil surveys in the Connecticut Valley, located areas about Hartford which it believed were suited to the growth of Sumatra tobacco. At that time it had never been grown in the region, and was not supposed to be adapted to it. During the past season the experiment was undertaken, in co-operation with the Connecticut State Experiment Station, on about a third of an acre. This was shaded from the sun by erecting a framework upon which cheese-cloth was stretched at a distance of about nine feet above the ground, and inclosing the sides as well. The tobacco grew well, and in due time was harvested and fermented as is customary. The quality of the finished product was pronounced excellent, and hardly to be distinguished from the imported article. As a substantial proof of this the crop has just been sold to a dealer at an average price of 71 cents per pound, including tops, butts and trash, along with the choicer leaves. As much as $1.25 per pound was received for some of the unsorted product. The average price received for the regular tobacco crop grown in the locality is about 20 cents. The Sumatra tobacco gave a net profit at the rate of nearly $900 an acre, exclusive of the expense of erecting the shade. The framework will last several years, but the cheese-cloth will have to be renewed each year. The object of shading this tobacco is to produce a thin leaf with small veins and a more luxuriant growth. Shading simulates the natural conditions under which it grows by making the atmosphere more humid and less subject to sudden changes. The Sumatra leaf is used for cigar wrappers, and is especially valued because it is elastic, free from objectionable taste and aroma, has small veins, which reduce the waste, and the leaf cuts up to better advantage than the ordinary wrapper leaf on account of its shape. About six million dollars' worth of Sumatra tobacco is imported annually, upon which a duty of $9,000,000 is paid. The experts in the Division of Soils estimate from their surveys that there is sufficient soil adapted to its growth in Connecticut and Florida to produce all that is demanded. This year's success will undoubtedly stimulate attempts to grow it regardless of the adaptation of the soil, so that there are likely to be many failures and disappointments another season, unless the advice of the Department is followed.

AN interesting chapter has been added to the knowledge of the inert gases of the atmosphere by Dr. Ramsay, the co-discoverer of argon, and Dr. Travers. A little more than two years ago they announced the discovery of krypton and neon, and at the same time obtained indications of two other gases, to which they gave the names of met-argon and xenon. They now find that the presence of the so-called met-argon was due to carbon in the phosphorus used for removing the oxygen. By the use of large quantities of liquid air they have, by fractional distillation, obtained sufficient amounts of krypton and xenon to study their properties and measure their physical constants. They are all monatomic gases, and in their inertness completely resemble argon and helium. The spectra of these elements have been exam-

ined and will shortly be published. The neon tube is extremely brilliant and of an orange-pink hue, and its spectrum is characterized by a multitude of intense orange and yellow lines. The krypton tube is pale violet, while that of xenon is sky-blue. The atomic weights of krypton and xenon are, respectively, 82 and 128, and the inert elements thus form a regular group lying between the halogens and the alkalies. The atomic weights are as follows: Helium, 4; neon, 20; argon, 40; krypton, 82; xenon, 128. Their physical properties also correspond with this grouping.

THE daily papers have during the past month exploited with nearly equal prominence Mr. Tesla's pretended communications from the planets, the alleged discovery by Professor Loeb of an elixir of life, and Professor Pupin's important discovery improving the telephone and the telegraph. These three cases pretty well represent the different methods of newspaper science. Mr. Tesla likes to be advertised, and the arraignment of his vagaries by our correspondent, published in another column, is none too severe. Professor Loeb and Dr. Lingle have carried out valuable researches on the action of salts on muscular contraction, published in the 'American Journal of Physiology,' and these have been exaggerated and distorted in the daily press. We are requested by Professor Loeb to state that this has been done without his knowledge, and continued in spite of his earnest protest. Professor Pupin's discovery is reported with substantial accuracy as regards its nature, its importance, and the large sum paid by the American Bell Telephone Company for the patent. Professor Pupin's discovery was made in the course of a long theoretical and experimental investigation, carried on solely to increase our knowledge of electrical phenomena and without any reference to the Patent Office. The researches were communicated to the American Institute of Electrical Engineers last spring, and published in their 'Proceedings.' The application consists in the use of self-induction coils at regular intervals along a wire which counteract its capacity and maintain the distinctness of the electric wave. It is thus possible to telephone to San Francisco as distinctly as can now be done to Chicago, and in the use of lighter wires to Chicago alone hundreds of thousands of dollars are saved in the cost of copper. Underground wires for telephony can now be used, and ocean telephony is made possible.

THE scientific societies, whose midwinter meetings are described above, have elected the following presidents for the ensuing year: American Society of Naturalists, Prof. W. T. Sedgwick, of the Massachusetts Institute of Technology; American Morphological Society, Prof. J. S. Kingsley, of Tufts College; American Society of Bacteriologists, Prof. W. H. Welch, of the Johns Hopkins University; Society of Plant Morphology and Physiology, Dr. Erwin F. Smith, U. S. Department of Agriculture; Folk-lore Society, Dr. Frank Russell, of Harvard University; American Psychological Association, Prof. Josiah Royce, of Harvard University; American Mathematical Society, Prof. E. H. Moore, of the University of Chicago; American Chemical Society, Prof. W. F. Clarke, of the U. S. Geological Survey; the Geological Society of America, the Hon. Charles D. Wolcott, Director of the U. S. Geological Survey. —Porf. E. E. Barnard, of the Yerkes Observatory, has been awarded the Janssen prize of the Paris Academy of Sciences for his discovery of the fifth satellite of Jupiter.—Dr. G. A. Miller, of Cornell University, has been awarded the mathematical prize of the Academy of Sciences, at Cracow.—Prof. H. C. Bumpus, of Brown University, has been appointed curator of invertebrate zoology and assistant to the president in the American Museum of Natural History, New York.—We record with regret the death of Lord William Armstrong, inventor of the gun that bears his name

and of hydraulic machinery, and of Mr. William Pole, an eminent engineer and man of science, best known, perhaps, to the general public as the author of the 'Evolution of Whist.'—Mr. John D. Rockefeller has made a further gift of one and a half million dollars to the University of Chicago.—Among the public bequests made by the late Henry Villard are $50,000 each to Harvard and Columbia Universities.—The Huxley Memorial Committee announces that the sum of about $17,000 has been subscribed for the statue now in the Natural History Museum, London, and for the Huxley gold medal to be awarded by the Royal College of Science.—The collection of minerals and meteorites made by Mr. Clarence S. Bement, of Philadelphia, has been acquired by the American Museum of Natural History, New York.—The Duke of the Abruzzi proposes to start from Buenos Ayres in 1902 on a voyage to explore the South Polar Seas. A ship is to be built in Italy for the purpose.—Drs. Sambon and Low have returned to England, after the summer spent in the mosquito-proof hut in the Roman Campagna. They are in excellent health, though it is said that the past summer was exceptionally malarious. For example, fifteen or sixteen police agents were sent to Ostia, and though they only remained a night in the place, they all developed fever.—The daily papers report that the Finlay theory of the propagation of yellow fever by mosquitoes has been further confirmed by the commission now studying the subject in Cuba. Cable despatches state that a monkey which had been bitten by an infected mosquito developed on the fourth day well-marked symptoms; that of six non-immunes bitten by mosquitoes which had previously bitten yellow fever patients five developed yellow fever, while subjects who slept in infected clothing and bedding, but were guarded from mosquitoes, were untouched.—